PRACTICAL GEOGRAPHY

A TEXTBOOK FOR SECONDARY SCHOOLS

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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Geography Panel

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FOREWORD

THE present publication is one of a series of four geography textbooks meant for higher secondary schools in India. This series of books is the result of the work done by the Geography Panel constituted under the Chairmanship of Professor George Kuriyan, Head of the Department of Geography, University of Madras. The panel has worked for more than three and a half years to develop a syllabus and prepare these textbooks.

The draft syllabus framed by this panel of specialists was finalized in the light of the suggestions received from the State Boards of Secondary Education, the State Departments of Education and a large number of training colleges.

The drafts of the textbooks were discussed and modified in several seminars attended by the members of the panel, and by authors, reviewers, teachers and principals of schools.

The other three books in the series on physical, economic and regional geography, will be published in due course. The present series is, in fact, part of a wider undertaking of the National Council of Educational Research and Training to help develop modern school curricula and model textbooks based on them, keeping in view the rapidly changing needs of our times.

The National Council wishes to thank Professor George Kuriyan and his colleagues for their valuable contribution to the preparation of these geography books. Thanks are also due to the State Departments of Education who co-operated with us in getting these books reviewed by competent teachers before they could be brought out in the present form.

The National Council invites suggestions from teachers and educators for the further improvement of these books.

L. S. Chandrakant

PREFACE

THE world in which we live today is certainly shrinking very fast. Astronauts now circle our planet in just 90 minutes. The rapid strides made in the field of technology have opened up new possibilities of making life more and more comfortable and meaningful for millions and millions of our fellow beings with whom we have to share this earth and its resources.

A systematic study of our planet, the unique physical conditions which are responsible for the evolution and sustained growth of life on the earth, its lands and peoples, its resources and their utilization by man, is, therefore, a must for every citizen of the world.

In this context, the contribution of Geography as a discipline can hardly be overemphasized, particularly when growing cultural, political and economic ties among nations are becoming more and more intricate, promising better prospects on the one hand, and threatening the total annihilation of mankind owing to regional rivalries, ideological conflicts and racial prejudices, on the other.

Unfortunately there are still misgivings about the very nature and importance of Geography both at the school and college levels in our country. In a large measure, the situation as it exists today, may be ascribed to the lack of good textbooks. These, besides serving our own needs, may help to locate the subject of Geography in its proper place. Under the circumstances I could not help accepting the request of the National Council of Educational Research and Training to take up this assignment.

It is, indeed, a difficult task to prepare only one syllabus and a single textbook that may serve the needs of every part of our country, particularly when there are different patterns with emphasis differing from region to region. None the less, this Panel devoted much time and thought to arrive at a common syllabus and produce a textbook that would generally be acceptable to all.

The original chapters of the book were written by Shri N. Prasad and Dr. R.N. Mathur, both from the Department of Geography, Banaras Hindu University, Shri J.B. Kumthekar, Department of Geography, Fergusson College, Poona; Shri S.C. Gupte, Department of Geography, University of Poona; Dr. M. Anas, Department of Geography, Aligarh Muslim University; Km. C. Narayanamma, Queen Mary's College, Madras; and Shri B.S. Parakh and Mrs. S. Goyal, both of the National Council, New Delhi. The chapters were written under the overall supervision of the members of the Panel at the respective places. The authors and members of the Panel spent several days in discussing the drafts of the text. Original drafts went through several stages and were modified in the light of the deliberations held by the members of the Panel. Criticisms and suggestions that were received from experienced teachers and headmasters from time to time were also carefully looked into.

I am thankful to the members of the Panel and the authors for their co-operation. Among others, my thanks are also due to Shri M.K. Natarajan, Principal, Central School, Indian Institute of Technology, Madras; Shri M.L. Renjen, Principal, Air Force Central School, New Delhi; Shri P.R. Joshi, Principal, Central School, Nagpur; Shri T.G. Parande of H.H. School, Nagpur; Shri A.S. Hebbar of Indian School of International Studies, New Delhi; Shri M. Raza of Kashmir University; and Dr. U.K. Bose of the India Meteorological Department, New Delhi, for their valuable criticisms and suggestions for the improvement of these books.

Thanks are also due to Shri E. Dayal and Shri Krishan Kumar of the Department of Human Geography, University of Delhi, who did all the cartographic

work connected with these books and co-operated with me in every way. Shri D.M. Sonak prepared the pictorial illustrations. I am also thankful to a large number of agencies, Indian and foreign, for giving us the pictures for incorporation in the books.

To bring the manuscripts to their present form involved a good deal of editorial and related work, such as selecting pictures, sketching suitable diagrams and weaving them into the text, framing exercises and compiling appendices. I am thankful to Shri B.S. Parakh of the National Council, who rendered invaluable help to me in this task, besides looking after the large amount of correspondence involved in this project. But for his help, it would not have been possible for me to bring out the book in its present form. He was assisted by Mrs. S. Goyal and Shri S.S. Rastogi.

I am thankful to the officials of the National Council: Shri P.N. Kirpal, Director, National Institute of Education; Shri L.S. Chandrakant, Joint Director; Shri P.N. Natu, Secretary, National Council; Mrs. Muriel Wasi, Officer on Special Duty, National Council, Shri R.N. Vij, Assistant Secretary, Professor B. Ghosh, Head of the Department of Curriculum, Methods and Textbooks and Dr. R.H. Dave, Head of the Department of Curriculum and Evaluation for their ungrudging help and co-operation in the execution of this project.

George Kuriyan

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INTRODUCTION

Tools and Techniques of Geography

EACH discipline, that is, each branch of systematised knowledge, has certain tools and techniques on which it depends to further its basic objectives. Geography, too, has certain devices of its own. Important among them are globes, maps, diagrams and relief models. *Practical Geography* is concerned with the study of these tools and also the techniques that are involved in their construction and use.

A globe is a man-made model of the earth—his closest approximation to the earth itself. Being a model, it can be seen and comprehended very easily.

As the globe represents the shape of the earth fairly accurately, it shows correctly the shape of oceans and continents. It enables us to make comparisons of areas of various units of the earth. It shows the correct positions of places on the earth in relation to one another.

Nowhere do we get a better idea of parallels of latitude and meridians of longitude than on the globe itself. The intersection of meridians and parallels at right angles results in the formation of a grid. A grid, in turn, enables us to determine the location of any point on the earth.

Furthermore, the globe makes it easy to understand what a great-circle route is and how it is measured by just stretching a piece of string between the two given points on the globe.

It is said that the earliest globe was made by Crates in Greece about the year B.C. 150. Later it was practically forgotten for several centuries. Today, however, it has found its way into almost every classroom.

Another tool which is absolutely indispensable to the geographer is the map. Although less accurate than the globe, it has certain advantages which make it more useful than the globe itself. In fact, it is a proven tool which is widely used in other fields as well.

Today, we take maps for granted because they are in common use. The story of maps, however, takes us nearly 4,000 years back in history. The earliest known map, that is still preserved, shows a portion of Iraq. This map is in the form of a small tablet of baked clay. It was made about 2,500 years before Christ.

According to its definition, a map is a representation of the earth or a portion of it, drawn to scale on a flat surface. A map is particularly useful in representing small areas as against the globe representing the entire earth. Moreover, unlike the globe, maps can be bound easily in atlases or incorporated in books of any size.

A georgrapher uses a map as a base to record a variety of facts or data. These data relate to geographic elements. Geographic elements are of two

types, the natural and cultural. Important among the natural or physical elements are relief and drainage, soils and mineral ores, climatic phenomena and natural vegetation. The cultural or man-made elements include land use patterns, sources of irrigation, lines of communication, settlements and distribution of population, political and administrative boundaries and a large variety of human institutions.

A map is used to plot one or several of these elements. A map-maker depicts them on a map in a symbolic language which is followed almost universally. He plots the data according to their areal occurrence, that is, the area in which they are found.

A map-maker may record the data either directly from the field or from some secondary source such as the census report or the land returns. For a student of geography, practice in plotting data on a base map provides a fuller understanding of the map as a medium of communication.

Recording of data, their numerical value with their variations enables a map to contain a wealth of information in a small space. Perhaps the greatest advantage of a map is that it reduces the landscape patterns spread over hundreds of square kilometres to a few square centimetres, a size which is small enough to visualize large areas at a glance and as a whole, so as to establish meaningful areal inter-relationships among the various parts.

These special properties of a map make it possible for a geographer to use it as an analytical device. He studies maps to analyse the concentrations and sparsity of each geographic element and correlates it with the other. He studies the relationships of various geographic elements from place to place, or from area to area and establishes areal or spatial relationships.

This analytical study of a map helps the geographer to note the spread and distribution of various geographic elements, observe their frequency, density or intensity as the case may be. He is thus able to identify and outline regions with specific characteristics.

For example, a mountainous tract, a river basin, a grassland, a semi-arid region, an urban area and an industrial zone, are some of the basic generalizations of geography derived essentially through the technique of mapping.

A map is also used by a geographer to present the findings of his study. This illustrative function of a map is well known. It, however, involves the ability to read and interpret maps on the part of its users. A map, it must be remembered, contains a mine of information only to those who know its language and its essentials.

A map to be complete needs a title, a key or a legend, a scale, a grid and direction.

The purpose of a map title is to explain what the map is about. A legend or a key of a map explains what each symbol used in a map stands for. The scale mentioned on the map enables its readers to measure distances and compute areas. The arrow drawn on a map or a plan indicates the direction of either the True North or the Magnetic North.

Although it is only a two-dimensional device, a map is also made to give a good idea of the third dimension, viz., the altitude and relief of the area represented on the map.

Finally the proper appreciation of maps involves the understanding of principles and techniques employed in portraying the curved surface of the earth on to a flat surface. It is here that the knowledge of map projections and various grid systems becomes necessary.

In this context, it is interesting to note the origin of the word *map*. It is derived from the Latin word *mappa* meaning a 'napkin' or 'covercloth.' Thus the word *map* rightly suggests what covers the earth or a part of it. In this sense a map may be compared to a skin of the earth, peeled off as it were, and flattened to give a plane surface.

The earliest maps were somewhat crude. The modern science of map-making, known as *cartography*, gradually came into being after Mercator's world chart was constructed in the year 1569. Currently this science is becoming highly technical and specialized. It is central to the entire field of geography.

Charts, diagrams and relief models are some of the other tools of geography. These tools are used mainly for purposes of illustration. They are particularly useful as visual aids to learning. The presentation of data in the form of charts and diagrams enables one to compare and correlate various geographic elements and establish their interrelationships.

Block diagrams are drawn in perspective as a block of the earth's crust. The upper edges of the block provide surface profiles. The block as a whole provides a bird's eye view of a large area. Sometimes the edges of the block are made to show what lies below the surface. Such block diagrams help us to correlate the relief features with the underlying rock structure.

Relief models actually possess the third dimension. They are used to show the actual configuration of the land surface of a limited area. Sometimes they are also used to show the relief of a country or a continent as a whole. In such cases the relief shown is highly generalized. Furthermore, it may be remembered that the vertical scale of relief models is highly exaggerated as compared to the horizontal scale.

A careful study of the following chapters may provide enough material to develop an elementary understanding of the basic principles and techniques which a geographer has to employ in his work as a scientist.

The chapters on scale, surveying, projections and graphical representation of geographical data may provide the necessary grounding in the principles of map making. The last chapter in this group may also initiate a student of geography in the construction and interpretation of charts and various diagrams that are useful both in economic and physical geography.

The chapter on the study of maps offers an opportunity for the student to acquaint himself with the conventional signs and symbols used in maps, particularly the topographic sheets issued by the Survey of India. A practice in map study should enable him to visualize from the map the natural features of the landscape.

The chapter on weather study, it is hoped, will help him to handle various weather instruments, record readings and understand the meaning of climatic data which he will often come across.

Finally the chapter on local geography will give him an inkling into the task of a geographer working on new frontiers of knowledge—breaking new ground, exploring new ideas and perhaps imparting a new meaning to common phenomena.

CHAPTER 1

Scales : Their Use and Construction

A MAP is a conventional representation of any area of the earth's surface, small or large, drawn to scale on a flat surface as seen from a position vertically above. It may represent, through its conventional symbols, only a few, or several features on the earth's surface. Very often, it contains names of these features for purposes of clarity and identification. It gives at a glance a good amount of accurate information in the limited space available on a flat piece of paper. This is why it is often said that a map contains a mine of information, but it can only be read and understood by one who knows its language.

For a long time, map making was something of an art. But today with the development of new techniques this art has acquired a scientific character. Now the map maker employs not only his skill but also scientific methods by which he processes his data and presents the same in the form of a map.

Scales

Maps are drawn to scale. A *scale* is the ratio which the distance between any two points on a map bears to the actual distance between the corresponding points on the ground. Thus, when we speak of the scale being one centimetre to a kilometre, we mean that two points one centimetre apart on the map, are one kilometre apart on the ground. Remember, all scales on the map are linear scales.

Before compiling a map, the first essential consideration is to determine the scale to be used. The two necessary things to be taken into account are the extent of the ground to be depicted and the size of the paper on which it is to be shown. Thus the amount of detail which can be shown also depends entirely on the choice of the scale. A large-scale map will show a smaller area in more detail as compared to a map on a smaller scale.

The map scale may be expressed in one of the following three different ways : (*i*) by a statement, (*ii*) by a numerical fraction and (*iii*) by a graphical section.

By a statement : In this method, the scale or ratio is stated in words such as one centimetre to four kilometres or six inches to a mile. This indicates that in the former case one centimetre on the map corresponds to four kilometres on the ground, whereas in the latter, six inches on the map correspond to a mile on the ground. This method can only be used by those who are familiar with the particular unit of measurement adopted.

By a numerical fraction : This is sometimes referred to as the *Representative Fraction* and is usually abbreviated as *R. F.* It gives the proportion between the distances on the map and the corresponding distances on the earth's surface in the form of a fraction, whose numerator is always unity, that is, one.

The numerator 1 represents the distance on the map while the denominator indicates the actual distance on the ground. Thus

$$R.F. = \frac{\text{Distance on the map}}{\text{Distance on the ground}}.$$ In other words, the numerator denotes the unit of length on the map and the denominator indicates the number of times the numerator must be multiplied to show the actual distance on the ground measured in the same units.

It may be written either as $\frac{1}{1,000,000}$ or 1 : 1,000,000. This means that one unit on the map represents 1,000,000 of the same units on the ground. This unit may be an inch or a centimetre or any other unit. The only thing which should be taken into consideration is that the unit of distance for the numerator and denominator must be the same. Hence this method of stating the scale is independent of any particular unit of measurement. It can be converted into any unit and, therefore, in reading and making maps it has a universal application, that is, it can be used by any country according to its commonly accepted unit of measurement.

Worked Examples

1. Calculate the R. F. when the scale is five centimetres to one kilometre.

The scale of the map is 5 centimetres to 1 kilometre, i.e., 5 centimetres on the map represent 1 kilometre, i.e., 100,000 centimetres on the ground.

Now in R. F. the numerator, that is, the map distance is always one.

$$\therefore \text{R.F.} = \frac{\text{Distance on the Map}}{\text{Distance on the ground}}$$

$$= \frac{5}{100,000}$$

$$= \frac{1}{20,000}$$

or 1 : 20,000

2. The scale of a map is one inch to two miles. Find the R. F.

The scale of the map = 1 inch to 2 miles, i.e., 1 inch on the map represents 2 miles on the ground measured in the same units.

As the unit on both the sides of ratio must be the same, convert 2 miles into inches.

$\because$ 1 mile = 63,360 inches

$\therefore$ 2 miles = $2 \times 63,360$ = 126,720 inches

that is, 1 inch on the map represents 126,720 inches on the ground.

Now the R. F. is always expressed in terms of a fraction in which the numerator is one.

$$\therefore \text{R. F.} = \frac{\text{Distance on the Map}}{\text{Distance on the Ground}}$$

$$= \frac{1}{126,720}$$

or 1 : 126,720.

3. The scale of an Indian map is one centimetre to ten kilometres. Convert this scale into the British System of units.

The scale of the Indian Map = 1 centimetre to 10 kilometres, i.e., 1 centimetre on the map represents 10 kilometres or 10x100,000 centimetres on the ground.

$\therefore$ R. F. = $\frac{1}{1,000,000}$ or 1 : 1,000,000

Conversion of R. F. 1 : 1,000,000 into British System means that 1 inch on the map represents 1,000,000 inches on the ground.

$\because$ 1 mile = 63,360 inches

$\therefore$ 1 inch on the map represents $\frac{1,000,000}{63,360}$ miles on the ground.

= 15.78 miles on the ground

Hence the scale of the map in the British System of measurement is 1 inch to 15.78 miles or 1 inch to 15.8 miles approximately.

By graphical section or linear scale : On maps, in addition to the statement or the numerical fraction, it is generally convenient to give a graphical section or a linear scale. The *linear scale* is a line conveniently divided and sub-divided so that distances on the map can be directly measured and read off from the map in terms of distances on the

ground. This scale has the great advantage of remaining true even after reduction or enlargement of a map by photographic processes. But this method, like the statement of scale, has a limited scope, as this is useful only to those who are familiar with the particular unit of measurement employed.

In constructing a graphical scale the scale line should be of convenient length and sufficiently long so that the distances on the map can be read easily from it. It should be about 12 to 20 centimetres, or 5 to 9 inches long. It should represent a convenient round number of units used either in kilometres or in miles. These should usually be in tens, hundreds or thousands so that divisions and sub-divisions are easily possible. For easy measurements, the primary divisions of the line should always be on the right side of zero. The secondary divisions which are sub-divisions of one of the primary divisions should be to the left of the zero mark (Fig. 1).

Worked Examples

The R. F. of a map is 1/633,600. Construct a graphical scale with primary and secondary divisions to read up to two kilometres.

R. F. $=\frac{1}{633,600}$, i.e., one unit on the map represents 633,600 units on the ground.

$\because$ 1 centimetre on the map represents 633,600 centimetres, i.e., $\frac{633,600}{100,000}=6{\cdot}336$ kilometres on the ground. Hence the scale of the map is 1 cm. to 6.336 km.

As stated above the convenient linear scale-line is usually between 12 and 20 centimetres in length. Supposing the length of the scale-line is 12 cm., it will represent 12×6.336 km. $=76.032$ km.

This is an odd number and not convenient for the construction of a scale. Therefore, take a round number nearest to 76.032, say 80.

Now to construct a linear scale for 80 km. we must determine how many centimetres will represent 80 km.

6.336 km. are represented by 1 cm.

$\therefore$ 80 km. are represented by $\frac{1\text{x}80}{6.336}$

$=12.56$ cm.

or 12.6 cm. approximately

Linear Scale

Draw a straight line AB of 12.6 cm. in length. From A draw another line AC making a convenient acute angle BAC. On AC mark off eight equal divisions (a, b, c, d, e, f, g and h) by means of a pair of dividers. Join the last point h to B and from the other points (a, b, c, d, e, f and g) draw lines parallel to hB to meet the line AB. These parallel lines will cut AB into eight divisions, each being equal to 10 kilometres. These are the primary divisions (Fig. 2).

To obtain the secondary divisions, subdivide the first primary division, i.e., the division on the extreme left into five equal parts as shown in the figure. Each of these secondary divisions will represent two kilometres.

While numbering the scale, zero should be marked after one interval from the left, so that the left-hand end of the line can be

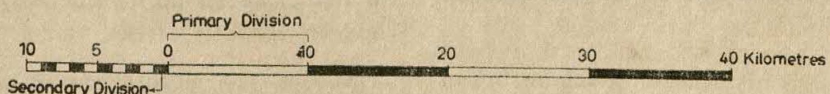

Fig. 1. Linear Scale with Primary and Secondary Divisions

Divisions to the right of the zero mark are primary, whereas sub-divisions to its left are secondary. Why ? How would you measure the distance of 24 kilometres on this scale?

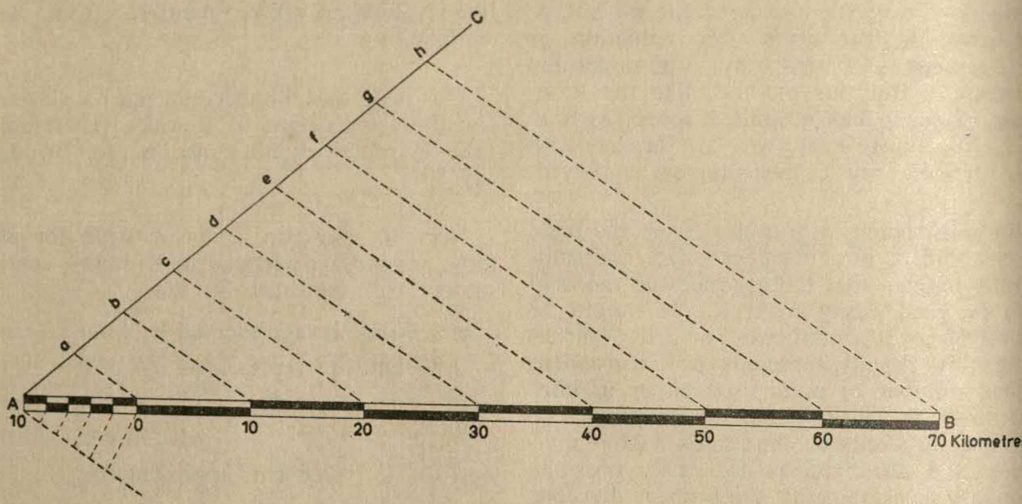

Fig. 2. Construction of a Linear Scale

How would you reconstruct this scale if a secondary division is to represent one kilometre?

numbered 10 and the primary divisions to the right of zero can have numbers 10, 20, 30, 40, 50, 60 and 70. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale. This eliminates the need to sub-divide all the primary divisions of the scale.

Diagonal Scale

Besides giving primary and secondary divisions, a *diagonal scale* gives divisions which are smaller than a secondary division. In this sense, this scale is an elaboration of the graphical scale and brings considerable precision in map-making. Fig. 3 illustrates a diagonal scale by which we can read up to one-fiftieth of a centimetre. If we take a line only one centimetre long instead of two, we may be able to read up to one-hundredth of a centimetre.

Draw a line AB equal to 2 centimetres in length. Draw AU and BV perpendicular to AB. On AU and BV mark off ten equal divisions of any convenient length and join the corresponding points of AU and BV by lines parallel to AB. Again divide lines AB and UV into ten equal divisions each equal to 0.2 centimetre and mark them as 0, 1, 2....and 10 from right to left as shown in Fig. 3. Now join 0 of line AB to 1 of line UV; 1 of line AB to 2 of line UV and so on as shown in the figure.

In this figure each division along the lines A B and UV is equal to 0.2 centimetre. Now take into consideration the small divisions obtaining to the right of the diagonal line 01. One space up the line AB, the distance between the diagonal line 01 and D is .02 centimetre; 2 spaces up the line AB at F it is .04 centimetre; six spaces up the line AB at N it is .12 centimetre and so on.

Suppose you want to measure a distance of 3.08 centimetres you may just have to add the distance between the diagonal line .01 and 1 (four spaces up the line AB) to three centimetres.

This is a very effective way of dividing a very short line into any number of parts but it must be remembered that the parallel lines, the perpendiculars and the diagonals must be drawn with accuracy.

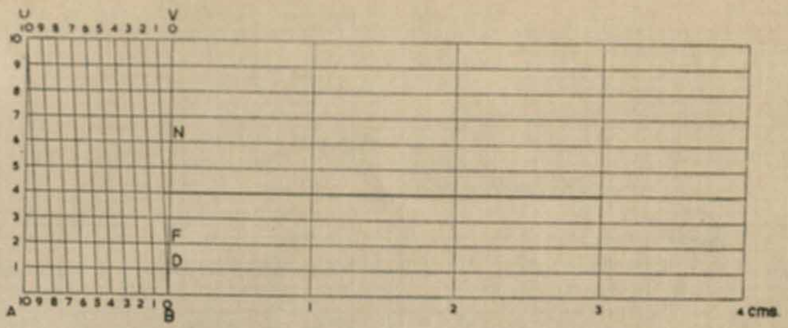

Fig. 3. Construction of a Diagonal Scale

With the help of this diagonal scale we can read up to one-fiftieth of a centimetre. Can we read also up to one-hundredth of a centimetre? How would you measure a distance of 2.47 centimetres?

Measurement of An Area

For detailed map study, it is occasionally necessary and also useful to measure the area of any feature depicted on the map. The area of a plot with regular sides can be calculated mathematically. But to calculate the area of a plot which is irregular in shape, mathematical calculations become laborious. One simple, but not very precise method to measure such an area is by means of squares. According to this method, the area is covered with squares either by tracing the outline on the graph paper or by superimposing the map on the graph paper over a brilliantly lighted tracing table.

Now, to calculate the area, first count the number of complete big squares, then the number of complete small squares which are within the boundary and for small incomplete squares take fractions, i.e., count as one each of those which are more than half within the boundary and ignore those which are less than half (Fig. 4).

Enlargement and Reduction

Frequently a map-maker is called upon to change the size of a map. Either he has to enlarge it or he has to reduce it. The changes in the size of a map, whether it is enlargement or reduction, can be done directly by means of instruments such as the *pantograph* and the *eidograph*. The most accurate and quick method is by *photographic* means. However, the simplest method is to do the enlargement or reduction by means of squares, i.e. the graphical method.

In this method, the original map is covered with a network of squares of any convenient unit. On another sheet of paper, a similar network of squares is drawn, enlarged or reduced, according to the desired scale. In this new network of squares the details are transferred carefully from the original, square by square, noting particularly any important intersection of detail with the grid lines. Thus, the change of scale of the length of the side of the square produces the desired amount of enlargement or reduction.

Suppose the map is to be reduced to two-thirds its original size. Draw a network of squares, each side measuring 1.5 centimetres, to cover the whole map area. On another sheet of paper draw similar squares, the sides of which are two-thirds the sides of the original squares. The side of each new square will now measure 1.0 centimetre. On this new network of squares, which is reduced to two-thirds its original size, transfer the details of physical and cultural features, square by square, in their correct perspective. Prominent features are first drawn lightly and then the

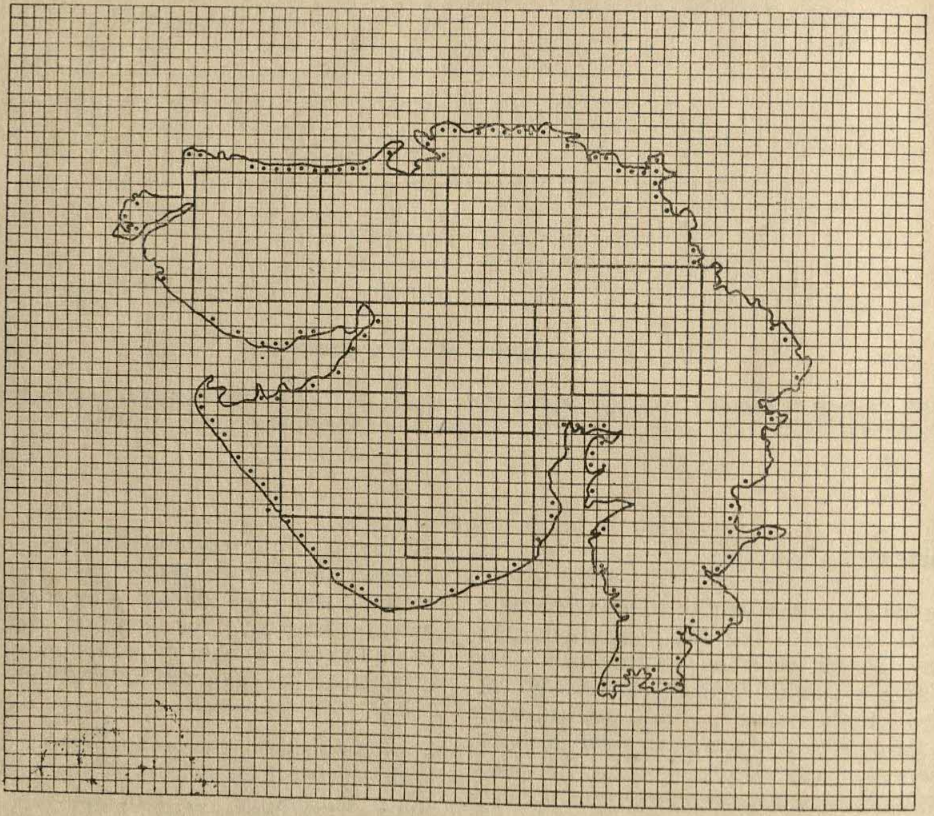

Fig. 4. Area Measured by Method of Squares

Seven complete big squares make it easy to measure the area depicted on the map. How would you find out the exact area of the entire region ? Why are the certain incomplete small squares marked with dots ?

minor details are filled in. The closer the grid, obviously the more accurate will be the result (Fig. 5).

In this method, the only calculation involved is to find out the length of the side of required square on the new scale. The formula for finding out the size is:

$$x = \frac{\text{New Scale}}{\text{Old Scale}}.$$

Worked Example

A map to be reduced has the R.F. $\frac{1}{63,360}$.

The R.F. of the new map will be $\frac{1}{190,080}$.

By what proportion is the reduction done?

The new scale is $\frac{1}{190,080}$.

The old scale is $\frac{1}{63,360}$.

$$\therefore x = \frac{\text{new scale}}{\text{old scale}}$$

$$= \frac{\frac{1}{190,080}}{\frac{1}{63,360}}$$

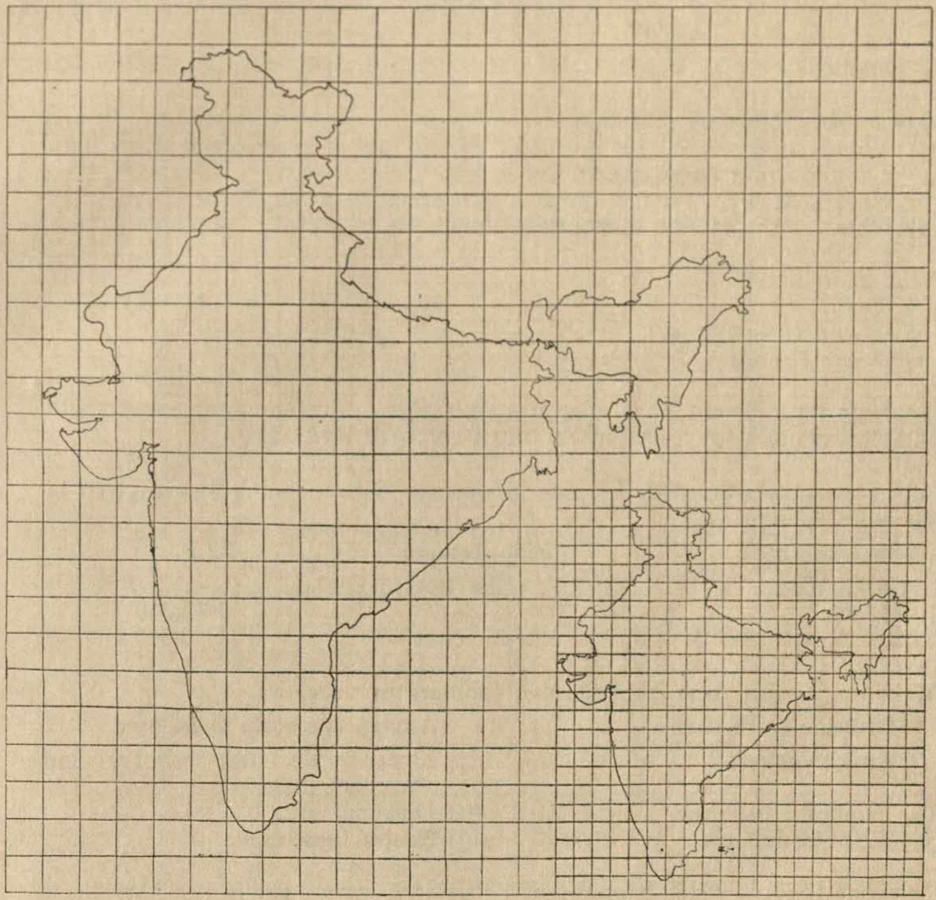

Fig. 5. Reduction of a Map by Method of Squares

The given map of India has been reduced to half its size. What would you do to enlarge the map to twice its original size?

$$= \frac{1}{190{,}080} \times \frac{63{,}360}{1}$$

$$= \frac{63{,}360}{190{,}080}$$

$$= \frac{1}{3}.$$

Hence the reduction is done by one-third.

EXERCISES

Review Questions

1. Answer the following questions:
   (*i*) What is a map? Why is it called the basic tool of geography? How does it differ from the globe?
   (*ii*) What is scale? What purpose does it serve on a map?
   (*iii*) What are the factors that govern the choice of scale?

2. Write short notes on :
   (*i*) R. F. ;
   (*ii*) Secondary divisions ;
   (*iii*) Diagonal scale.

3. What are the different ways of expressing scales? Illustrate your answer with suitable examples to bring out the merits of each method.

4. Fill in the blanks correctly keeping in view the corresponding figures given in the other columns:

Actual distance	Map distance	R. F.
(*i*) 4 kilometres	4 centimetres	—
(*ii*) 1 mile	—	1/63,360
(*iii*) —	6 centimetres	1/50,000

5. Make out correct pairs from the two columns given below:

Distance to be shown	Appropriate scale to be used
(*i*) 80 kilometres	(*i*) Linear scale with primary and secondary divisions
(*ii*) 3 miles 6 furlongs	(*ii*) Diagonal scale
(*iii*) 6.56 centimetres	(*iii*) Simple linear scale

6. Complete the following statement by choosing a correct ending :
   The R. F. is a convenient scale with a universal application because,
   (*i*) it does not require linear or graphical scale.
   (*ii*) it remains true even after reduction or enlargement of a map.
   (*iii*) it is independent of any particular unit of measurement.
   (*iv*) it makes it easy to measure directly the distances on the map.

Problems to be Solved

1. Find out the R. F. of one-inch, half-inch, and quarter-inch toposheets. Work out the statements of scale for each one of them in centimetres to kilometres.

2. The scale of a Russian map is one paletz to a verst. Find out the scale of this map in centimetres to a kilometre. Note that a verst is equal to 84,000 paletz.

3. On a table are kept three separate packs of paper containing 319, 321 and 317 thin sheets ready for binding. If the thickness of the paper is 0.01 of an inch, how would you find out the exact number of sheets in each pack without counting or weighing them ? Which tool or simple instrument, do you think, would help you in this case? See if you can devise the instrument yourself, explaining its construction.

Constructional Work

Draw outline maps of Madhya Pradesh and Maharashtra on graph paper.

(*a*) Find out with the help of method of squares, which of the two states is bigger.
(*b*) Enlarge the map of Madhya Pradesh to double its scale.
(*c*) Reduce the map of Maharashtra to half its scale.
(*d*) Find out the R. F. of these new maps.
(*e*) Prepare a linear scale with suitable primary and secondary divisions in kilometres for each map.

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CHAPTER 2

Surveying

SURVEYING IS an art of making observations and measurements both linear and angular, in order to determine the relative position of points on the earth's surface. Surveying helps to determine the boundaries, extent, position and relief of any part, big or small, of the earth's surface. The word survey actually stands for both the operation of taking the required measurements and drawing a plan to scale.

Surveying is, in fact, as old as the institution of private property. However, in course of time, surveying has become a highly technical and specialized job. A large number of instruments are being used these days to do this job as accurately and quickly as possible.

Today surveying has assumed great importance because it is undertaken for a variety of purposes. The location of new industries, factories, mills and refineries, the planning and execution of various multipurpose projects, the construction of railway lines, roads, dams and canals, the continual expansion of old towns and cities and the establishment of new townships, the development of ports and the opening up of mines have all contributed to the growing importance of systematic and highly technical surveys in our land. It is, perhaps, even more important from the point of view of the defence of our country.

Chain Survey

Many instruments are used in survey work; among them the chain is one of the more important ones. As compared to the more modern and highly technical methods employed in surveying, chain survey is an elementary and time-consuming method. It is generally used for surveying relatively small areas and for mapping details like boundaries of personal holdings, roads and canals with reasonable accuracy. It develops an insight into the task of a surveyor and the skills he has to employ in his work of surveying and mapping.

A *survey chain* is a device for measuring lengths, to determine the horizontal distances between two points. The chains are of various lengths. The length of the chain is the overall distance, when fully stretched, between the outside limits of the handles.

The chain is made of galvanized mild steel wire and has brass handles at both ends. It comprises a fixed number of links, each one consisting of a long piece, with one or three small rings at each end.

So far, two kinds of chains were in use in our country. They are the engineer's chain, which is 100 feet in length, and Gunter's chain, which is 66 feet long.

Under the British system of units, the Gunter's chain was found more convenient than the 100 feet chain, for land survey since 80 Gunter's chains make a mile and 10 square chains form an acre. ($10 \times 66^2 =$ 43,560 sq. feet=1 acre.)

Metric Chains

Recently, chains of 30 metre and 20 metre lengths, according to metric units, have

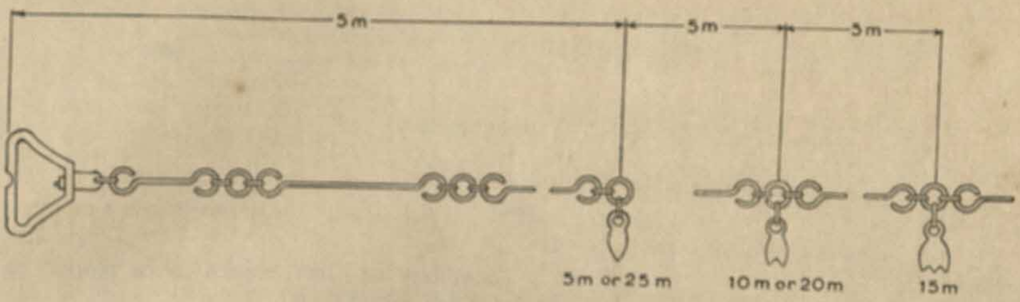

Fig. 6. Parts of the Chain *(After Indian Standards Institute.)*

Each large link is connected to the next by a small circular ring. How do tallies help in measuring the distance from either end?

been standardized and introduced in our country. These chains roughly correspond to the Engineer's chain and to the Gunter's chain respectively.

In order to read fractions of a chain without any difficulty, tallies are fixed at every five-metre length and small brass rings are provided at every metre length except where tallies are attached. The tallies have distinctive shapes depending upon their positions in the chain as shown in Fig. 6.

Tallies are metallic tags or indicators of distinctive pattern attached to a chain at fixed points to facilitate the quick reading of fractions of a chain. The tallies are marked with letters 'मी' and 'm' in order to distinguish the metric chains from non-metric ones.

In a thirty-metre chain, tallies at the end of five metres from either end of the chain have one tooth and indicate five metres from either end, i.e., 5 or 25 metres. The tallies at the end of ten metres have two teeth and indicate ten metres from either end, i.e., 10 or 20 metres. The central tag with distinct shape indicates 15 metres. Thus these tallies help us in measuring the distance from either end of the chain.

On the reverse side of the surface of the handle is mentioned the total length of a chain, viz., 20 metres or 30 metres as the case may be.

A groove is cut on the outside surface of the handle to facilitate holding the arrows or chain pins in position with the handle of the chain. The radius of the groove corresponds to the radius of the arrows.

Tapes

Tapes are available in various sizes or denominations. They are made of either linen or of metal like steel or brass. Of these, the steel tapes are the best. Tapes of 15 metres length are common.

Tapes made according to British measures are also available in various denominations ranging from 3 feet to 100 feet. Among them, the tapes of 50 feet or 100 feet are common.

Ranging Rods

These are straight rods usually made of wood, shod with iron to enable it to be fixed securely in the ground. They are generally six feet or two metres in length. Alternate feet are generally coloured in red and white so that they may show up both against light and against a dark background. Sometimes flags are attached at the top (Fig. 7).

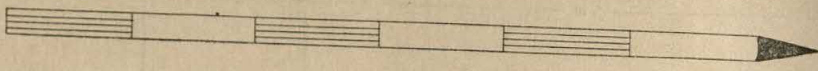

Fig. 7. A Ranging Rod

What is the significance of having red and white colours alternately on a ranging rod?

Arrows

Each chain is provided with ten arrows made of iron wire 15 or 18 inches long. These are well pointed at one end so that they may be easily driven into the ground. The other end of the arrow is curled into a ring to serve for a handle. The arrows are used for counting the number of chain lengths in a line.

Besides these instruments, a magnetic compass and an optical square are used in chain survey. While the former helps to determine the North point, the latter is used for finding out the points on the chain line from which the objects to be plotted along the chain line are at right angles.

Procedure for Chain Survey

Before undertaking any actual survey, the surveyors should prepare an outline sketch of the area to be surveyed. Although this sketch need not be drawn to scale, it should be reasonably correct and should show the details in correct perspective. The surveyors should also bear in mind that the underlying principle in chain survey is to divide the area into suitable triangles whose sides can be measured in the field and that all distances are measured horizontally on a level plane.

For having such a suitable triangle the surveyors must walk over the ground and ascertain that the points A, B and C of the proposed main triangle would be such that the triangle so formed would be as big as it can be obtained on the ground. Its sides should be such that there shall be no obstruction in measuring distances accurately. Moreover, each side, as far as possible, should lie near a boundary or other objects to be plotted on the survey (Fig. 8.).

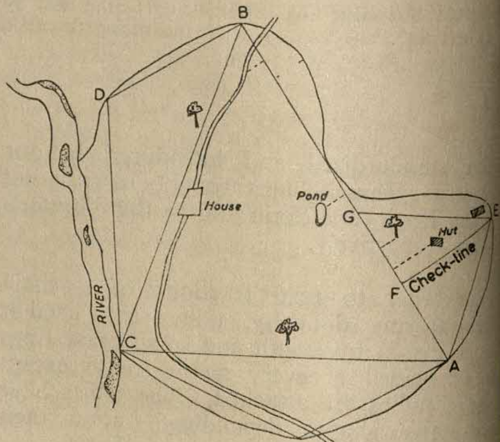

Fig. 8. Layout of Triangles for a simple Chain Survey

In chain survey the basic principle is to divide the area into suitable triangles. One of them should be as big as can be obtained on the ground so that it permits a few more subsidiary triangles to be built on to it. What is the purpose of a check-line?

If the main triangle satisfies most of these conditions, the actual task of surveying would become easy as it will permit a few more subsidiary triangles to be built on to it. It is further advisable to have a couple of check-lines as shown in Fig. 8 to discover errors, if any, in the measurements.

Once the survey is laid out and the ranging rods are fixed at their respective stations, A, B, C etc., two persons are required to conduct the actual survey. One who goes ahead dragging the chain after him is

called the *leader* and the other, the *follower*. It is interesting to note that, like a good citizen, it is the duty of the follower not only to follow his leader but also to see that the leader keeps on the straight or right path, i.e., in line with the ranging rod. The point from which the measurement begins is called the *starting point* and the other end of the straight line to be measured is the *closing point*.

The surveyors begin to operate according to plan when the follower holds the handle of the chain and stands over the station A, the starting point. The leader takes the other handle of the chain and ten arrows and proceeds in the direction of the closing point, i.e., station B.

When a chain length from the starting point is reached, the leader turns back and faces the follower to receive instructions from him to satisfy that he is in line with the ranging rod at B. The follower aligns the leader signalling him to move to the right or left by lifting up his right hand or left hand and the leader moves slowly in the direction indicated till the follower signals the leader down by putting down his hand. The position can be easily checked by the leader holding an arrow suspended from a handkerchief.

Having got into line, while the follower is holding the end of the chain firmly at the station, the leader lifts the chain, pulls it tight giving it a girth-wave motion with an up-and-down movement with the wrist of the hand. An arrow is fixed at the end of the chain.

Now, with the help of a tape, offsets are taken on either side of the chain line. An *offset* is a measurement taken at right angles to the chain line. Care is taken to see that the tape is held at right angles to the chain. An optical square is used for this purpose. It is used for setting out right angles for measuring short offsets from the chain line to any object nearby. Generally, offset readings are taken up to 15 metres or 50 feet on either side of the chain line. When measuring corners of buildings, it is advisable to take two measurements to the same point from two different positions on the chain line, one of which may or may not be an offset.

After having completed the offset measurements along the chain line, the leader drags the chain forward holding the handle leaving the arrow in position. The follower stations himself at the position of the first arrow and directs the leader, as before, in line with the station ahead and the same procedure is followed till they reach the closing point B of the chain line AB.

The follower goes on picking up the arrows and keeps them with him to know how many full chain lengths have been completed. The length of the chain line is determined from the number of arrows collected by the follower on his way, plus the number of links of the last chain, that remains incomplete till the closing point.

If the surveyors are using a chain with the British system of units and the follower has picked up six arrows and the distance between the last arrow picked up and the closing point is 38 links the total length of the chain line will be $6 \times 100 + 38 = 638$ links.

Field Notes

To enter the measurements, the field book is marked with two lines, about a centimetre apart, down the middle of the page. This space within the two lines is meant for entering distances along the chain line which are entered upwards from the bottom of the page. The space on either side of the central column is meant for entering offsets so as to correspond with each side of the ground along the chain line (Fig. 9).

A sketch of the boundaries is made on the right or left side of the page depending upon its actual position in relation to the chain line. The offsets are also entered on this sketch either to the right or left of the central column, as the case may be. At the bottom of the page the name of the line being surveyed is marked.

The primary object of keeping a neat field book is to ensure that the sketch and the

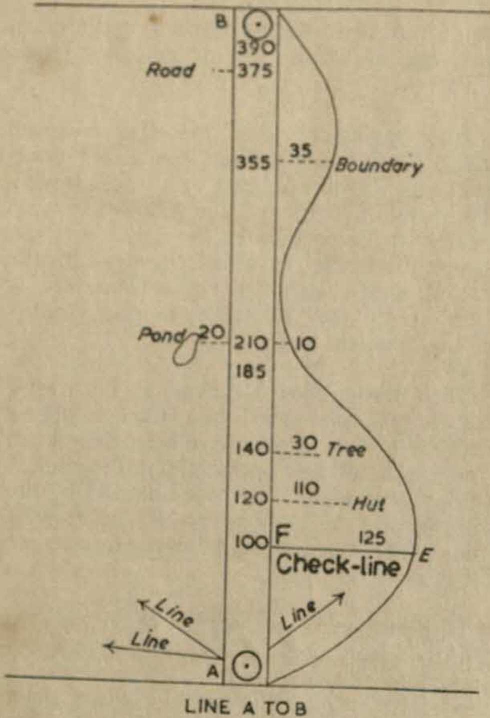

Fig. 9. Field Book for Chain Survey

The purpose of field book in chain survey is to enter the measurements of offsets along the chain line. How does a sketch of boundary line in field book facilitate actual plotting of the data on a map?

measurements progress hand in hand, line by line, never allowing the sketch to get ahead of the measurements or *vice versa*.

Plotting the Survey

The plan now to be plotted is a small representation of the important features of the area surveyed. Before actual plotting, a suitable scale is chosen according to the size of the desired plan and the actual area surveyed. When plotting the survey, a line to represent one of the longer sides of the triangles is first drawn on the paper according to the scale chosen and the other sides are drawn with reference to it.

The triangle ABC in Fig. 8 is drawn as follows:

First the line BC is drawn and then, with B as centre and BA as radius, a circle is drawn and then, with C as centre and CA as radius, another circle is drawn, which will cut the other circle at two points on either side of BC. The sketch must show which of these is the correct interesection to be chosen. After drawing all the triangles, the offsets from each chain length are marked according to scale and the whole plan is carefully completed with necessary details.

Plane Table Survey

To the student of geography, plane tabling is a highly useful field work. To him it offers an opportunity to draw a complete map while he is in the field itself. It provides him with the exciting experience of transforming a visible landscape into a map. A map drawn by this method is accurate and mistakes are rare because of the visible connection between the map and the landscape which could be easily tested while in the field.

A plane table consisting of a table-top and a tripod, a sighting rule known as alidade, a spirit level, a trough compass, a plumb-bob, a chain, a tape, and a few ranging rods and wooden pegs are the instruments and equipment needed for plane tabling (Fig. 10).

A plane table is a light flat drawing board placed on a tripod. The board can be rotated, and fixed by means of a screw in any desired position in the horizontal plane. It is set horizontal with the help of a spirit level. A plumb-bob is used to centre the plane table over the station marked on the ground.

The *alidade* is a strong flat ruler made of hard wood or metal. Its edges are perfectly straight and parallel. At each end it has flap sights which can be folded down when not in use. One of the flaps has a slit in the centre, while the other has a vertical hair, wire, or thread. Directions on the plane table are obtained by sighting the object in the field so that the eye of the observer, the vertical slit and the thread line are all in a straight line with the object.

A trough compass consists of a magnetic

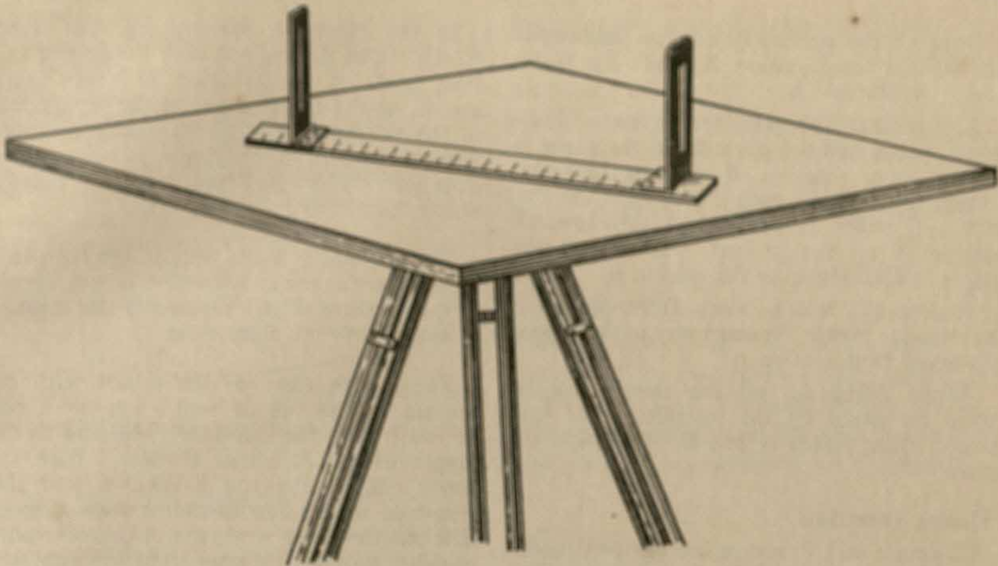

Fig. 10. A Plane Table and an Alidade (*After C. S. Fox.*)

Plane tabling enables to secure a reasonably accurate sketch map of a small area. It is also useful in filling the details into a network of triangles. How is the plane table oriented?

needle on a pivot in an oblong box with parallel sides and a glass lid. It is used for drawing a north-south line on the paper.

Procedure for Plane Tabling

First, make sure that all parts of the plane table are in order. Mount carefully a drawing paper on the board. It is advisable to take a sheet of paper larger than the board so that it can be folded and pinned or pasted down below the board.

Choose two convenient stations A and B on the ground to be mapped, so that a line joining the two may serve as a base-line. The stations A and B should be so selected that it would be possible to sight from both of them all important landmarks and objects on the ground. Measure the distance between A and B by a chain.

On a convenient scale, draw the line AB on the paper mounted on the plane table. While choosing the scale care must be taken to see that the area to be mapped would be properly represented on the paper. Set the table as nearly horizontal as possible, at *A* exactly over the station on the ground with the help of a plumb-bob. Place the alidade along the base-line AB drawn on the paper. Rotate the table-top round until the points A and B on the paper and the station B on the ground fall in one line. The table is then said to be *oriented.** Clamp the board in this position and check the sight again.

With the help of the alidade sight the important objects from point *A* on the paper. Draw every time a ray on the paper along the edge of the alidade. Label each ray with the description or name of the object which it points to. A Sketch diagram may help in the identification of rays. Care may be taken to draw the rays long enough to cover the distance between the station and the object per scale.

*It must be remembered that so long as *A* was not at the centre of the table, by rotating the table, the position of *A* would alter and will not be vertically over the station on the ground. The error should not be large; but if it is there, it can be corrected by shifting the paper slightly.

Once all the needed objects or landmarks are sighted from station A, shift the plane table to station B.

Ensure that the table-top is on a horizontal plane and the point B on the paper is exactly over station B on the ground. Orient the table in such a way that the line BA on paper is directed exactly towards station A on the ground, while B on the paper is vertically over the station B.

Repeat the whole work from station B by drawing rays in the same way to the objects observed from station A.

While doing so, all the points will be fixed on paper by the intersection of rays drawn from points A and B. Complete the plan.

Finding Directions

Distance and direction are the two fundamental components of surveying. After learning how to measure distances in the field, the next step would be to determine direction. No plan or survey is complete without showing the direction.

The four major cardinal points of direction are North, South, East and West. The directions are measured with respect to the north. The True North may be determined by different methods.

In the Northern Hemisphere, the True North can be determined with the help of the Pole Star. A constellation of seven stars known as the Great Bear can be recognized in the northern skies by its peculiar shape. The two stars in the front always point to the Pole Star. The Pole Star is located vertically above the North Pole (Fig. 11).

This method is useful only in the Northern Hemisphere as the constellation is not visible in the southern skies. Obviously this method is useful only at night time.

The North can be determined with reference to the sun as well. Fix up a rod vertically in the ground. Measure the length of the forenoon shadow. With the lower end of the rod as centre, and this length of the shadow as radius draw a circle. The length of the shadow will decrease until midday and will increase until the sun sets. The shadow will again touch the circle in the afternoon. Bisect the angle between the forenoon shadow and the afternoon shadow. The bisector is the true north-south line (Fig. 12).

This method is useful only at daytime and when the sky is free of clouds so that sun-shine can reach the earth unobstructed.

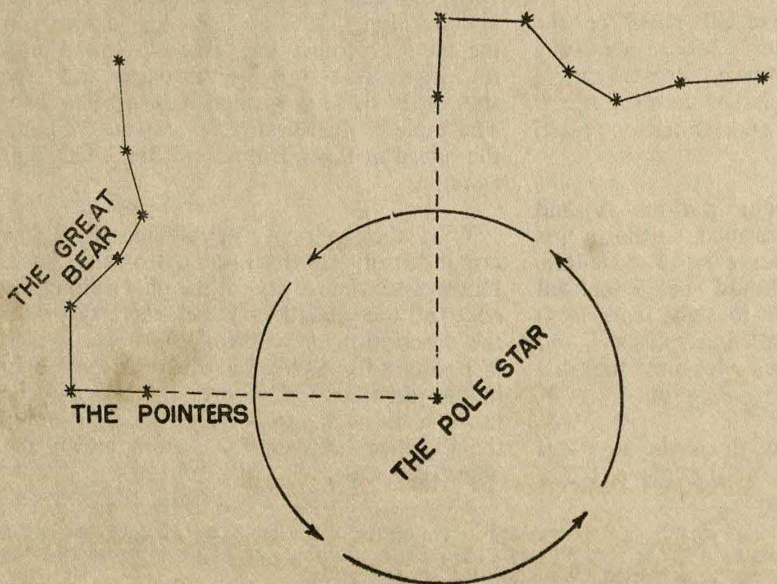

Fig. 11. The Pole Star and the Great Bear

In the Northern Hemisphere in northern skies the constellation of the Great Bear, popularly known as *Sapta Rishi Mandal*, keeps revolving round the Pole Star. The front two stars called the pointers always point to the Pole star. How does this star help to find the True North?

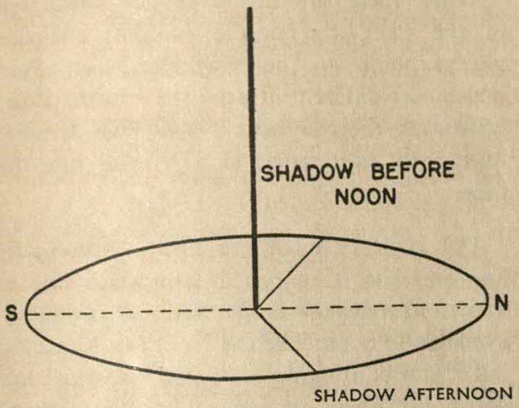

Fig. 12. The Shadow of the Rod and the North

The bisector of the angle between the forenoon and afternoon shadows touching the circle represents the true north-south line. How would you determine the north on this line?

A rough estimation of the direction of the true north can be obtained by means of an ordinary watch. In the Northern Hemisphere, the watch is held in a horizontal position and turned until its hour-hand points to the sun. The line that biscets the angle made by the hour-hand with the line joining 12 O' clock will point to the south. Similarly, in the Southern Hemisphere, the bisector of the angle formed by the hour-hand with the line pointing to the sun will indicate the True North. This is also a crude method dependent upon the sun (Fig. 13).

The most efficient way of finding the north direction is with the help of the magnetic compass. This instrument is not dependent on the Pole Star, the sun, or the clouds. The magnetic compass is the guide for a navigator, a surveyor and an explorer. It remains

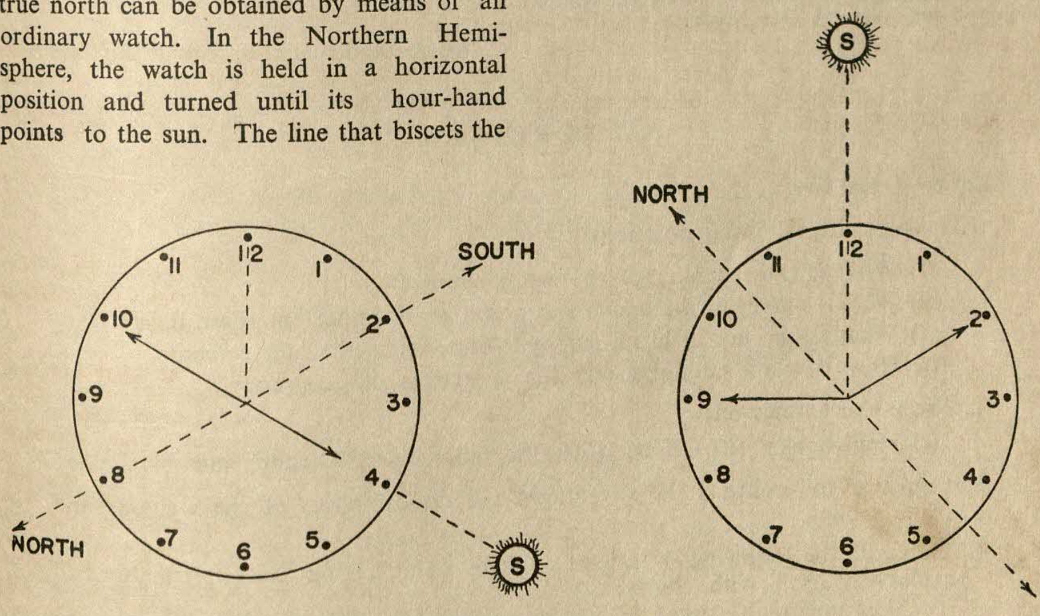

Fig. 13. Directions Determined by Means of a Watch

This method gives fairly accurate results at the time of equinoxes and near the equator. Why do you think this method cannot give accurate results?

the most useful instrument for fixing directions in surveys (Fig. 14).

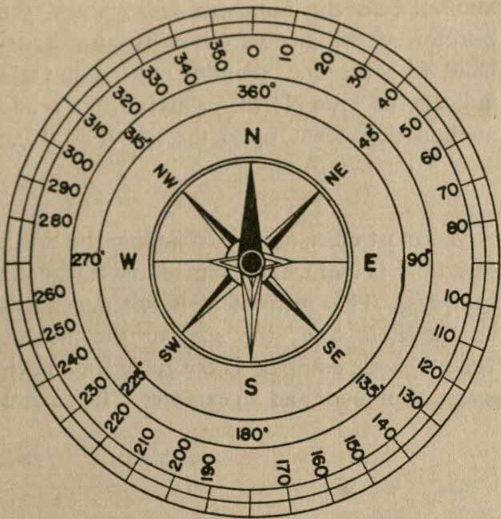

Fig. 14. Dial of the Magnetic Compass

The four major points of direction—North, South, East and West—are called the cardinal points. The magnetic needle always points to the Magnetic North. How will you know the True North?

When there are no magnetic substances in the field, the needle of the compass always points to the Magnetic North Pole which is different from the North Pole. Moreover, the Magnetic North Pole is not a fixed point as it moves slowly from time to time.

The angle between the True North-South line and the Magnetic North-South line is known as *magnetic declination.* It is directly available in books like the Nautical Almanac, but it can be roughly estimated also from the data furnished on each topographic map. Since it varies slightly from place to place and from time to time, such estimates are not accurate. Thus it is easy to find the True North once the Magnetic North is found, and the magnetic declination is known.

EXERCISES

Review Questions

1. Answer the following questions:

   (*i*) What is the meaning of the word survey?
   (*ii*) Why is surveying becoming more and more important these days?
   (*iii*) What is the use of chain survey? State its merits and demerits.
   (*iv*) How is plane tabling useful for a student of geography?

2. Write short notes on:

   (*i*) Field book; (*ii*) Offset; (*iii*) Orientation; (*iv*) Alidade; and (*v*) Tallies.

3. Compare and contrast the advantages and disadvantages of chain survey and plane tabling.

4. Elaborate the following statement, point by point, taking concrete situations to explain yourself with clarity:

   'The underlying principle in a chain survey is to divide the area into suitable triangles.'

5. Discuss the various methods which you may apply to find out the True North in the field.

6. Listed below in two separate columns are certain tasks to be performed by you, and the instruments or information at your disposal. Make out correct pairs from the two, ignoring the things that would not be of any help to you:

(*i*) Finding out the area of a piece of land in acres	(*i*) Gunter's chain
(*ii*) Keeping record of measurements taken in the field while surveying	(*ii*) Metric chain
(*iii*) Making a complete map of a small area in the field itself	(*iii*) Alidade
(*iv*) Ensuring that the top of the plane table is perfectly horizontal	(*iv*) Length of the check-line
(*v*) Centring the plane table exactly over the station marked on the ground	(*v*) Trough compass
(*vi*) Determining the True North from the Magnetic North	(*vi*) Optical square
(*vii*) Setting out right angles from the chain	(*vii*) Engineer's chain
(*viii*) Verifying the accuracy of the triangle laid out for chain survey	(*viii*) Magnetic declination
	(*ix*) Magnetic compass
	(*x*) Plumb-bob
	(xi) Spirit level
	(xii) Plane table
	(*xiii*) Field book

Problems to be solved

Suppose while surveying you are required to find out the width of a big pond several chains wide. How would you do it in the field using the chain, ranging rods and your knowledge of geometry in such a way that you need not enter the pond?

Field Work and Constructional Work

1. Survey the campus or play-ground of your school first with the help of a chain and then with a plane table. Complete the plans in all respects and compare them.

2. Prepare a plan from a field book already prepared for you by someone else. How will you verify the accuracy of the field book and your plan?

Films Available

(1) Setu Himachalam. No. 912; 10 mins; Hindi; D.A.V.E.

(2) Look at Life on the Map. No. 2569; 10 mins; English; B.I.S.

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CHAPTER 3

Map Projections

A GLOBE is the most satisfactory representation of the earth that has been devised so far. But a globe being cumbersome and not easy to carry about, maps are preferred. They can be easily handled and inserted in books and bound in atlases. Maps can be drawn to any scale and can be made to represent either the whole earth, or only a part of it, big or small. A map can be made to show a large number of details which a globe may not be able to represent ordinarily.

So far as the true and accurate representation of the earth is concerned, a globe is an ideal device since it has three dimensions like the earth. A map, on the other hand, is a two-dimensional device which attempts to represent only the outer skin of the earth that is peeled, as it were, from the curved suraface of the sphere and placed on a flat surface. It must be clearly borne in mind that no effort can flatten smoothly, such a curved surface entirely. Furthermore, when much flattening occurs, the geographic relationships shown on such a surface are bound to be distorted.

The important geographic relationships are : (*i*) shape of landmasses, water bodies, or political units, (*ii*) their areas, (*iii*) distances between any two places, (*iv*) directions which each place has to any other, and (*v*) locations of places or areas in relation to the entire earth.

Non-developable Surface of the Earth

A developable surface is one that can be opened out to form a flat plane, or it is a surface which can be covered with a sheet of paper without the formation of folds and creases. There are only three such surfaces, viz., a cylinder, a cone and a plane.

A sphere has a non-developable surface. It is impossible, therefore, to transform accurately the features from a sphere on to a plane. Whatever method is adopted, it is bound to be inaccurate in some ways. Although the earth is a spheroid, for all practical purposes, it is treated as a sphere, especially because its difference from the truly spherical shape is insignificant. The surface of the earth is said to be non-developable.

Thus, by the very nature and basic limitations of maps, it is impossible for any map of the earth to show the correct shape or form of land and water bodies. Moreover, it cannot be equally accurate with respect to area, location and direction, and at the same time show all the world on one continuous sheet without distortion.

In view of this reality, the cartographers whose job is to prepare maps as accurately as possible, have devised certain methods of drawing maps. These methods make it possible to retain exactly at least one or more of these relationships while transferring geographic features from the spherical surface to the flat sheet.

The basic geographic fact about any feature is its exact position or location on the earth's surface. The position of any point on the earth's surface can be accurately and fully defined with reference to a parallel of latitude and meridian of longitude, just as on a

graph, where a point is located with reference to x and y co-ordinates from an origin. Therefore, basic to any map is the principle according to which a network of these parallels and meridians are transferred or projected from a spherical surface to a flat one.

The method by which the network of parallels and meridians called the *earth's grid* is transferred or projected from the spherical surface to the plane, is technically known as a *map projection*. A map projection attempts to transfer, graticule by graticule, the features from the spherical earth to a plane sheet of paper. The term *graticule* is adopted for any area bounded by two parallels of latitude and two meridians of longitude.

Since no map projection is correct in all respects, a careful selection of a map projection always depends upon the purpose for which the map is to be drawn. This is particularly true when we are required to draw maps for large areas such as countries, continents, hemispheres, or the earth as a whole. In such maps even small errors are bound to get magnified and result in the distortion of one or more geographic features such as shape, area or size, and direction.

Classification of Projections

The knowledge of the classification of map projections according to their major characteristics, such as preservation of either area, or shape, or direction, therefore, becomes very useful. Map projections are usually classified into four groups—(*i*) Equidistant Projections, (*ii*) Equal-Area or Homolographic Projections, (*iii*) Correct Shape or Orthomorphic Projections, and (*iv*) True Bearing or Azimuthal Projections.

Equidistant Projections : It may be remembered that it is impossible to represent at a consistent scale all distances of the sphere on a plane. In equidistant projections emphasis is laid on retaining consistency of scale as far as possible. In these projections the scale is maintained in all directions from only one or two points.

Equal-Area or Homolographic Projections : In this group of projections a grid is developed in such a way that every graticule on the map is equal in area to the corresponding graticule on the sphere. In these map projections the quality of equal area is usually achieved by ignoring directions or distorting shapes.

Correct Shape or Orthomorphic Projections: In this class of projections every care is taken to preserve shapes. This involves changing the scale from point to point. It is seen that parallels and meridians cut each other at right angles and proper relationship between their lengths on the map and those on the globe is maintained. A constant ratio between the scales at any point is maintained, that is, if the parallel scale is exaggerated twice at a point, the meridian scale is also correspondingly exaggerated. But the scale ratio does not remain constant at every point : it varies. It may be 2 at one point, 5 at the other and 1/2 at the third.

True Bearing or Azimuthal Projections: In this category of projections correct bearings or azimuths, that is, directions, are preserved.

Just as map projections can be classified according to their major qualities or characteristics, they can also be classified on the basis of their construction. The ease with which a map grid can be developed is also an important consideration in selecting a map projection. The graticule on the sphere cannot be transferred satisfactorily on the flat surface directly in a single operation. Usually they are first transferred on developable surfaces. Thus we have another system of classifying projections on the basis of the actual process of projecting the globe over a plane surface.

The earth's grid is projected in three ways —(*i*) on a cylinder, (*ii*) on a cone and, (*iii*) on a plane itself; and these projections are called Cylindrical, Conical and Azimuthal or Zenithal, respectively.

Cylindrical Projections : In these projections a cylinder is presumed to have enveloped or cut the globe in a particular

manner. A cylinder on which the globe is projected is cut open along a line running from the base to the apex and a cylinder thus developed becomes a rectangle.

Conical Projections : In these projections, it is supposed that a simple cone either rests or interesets the globe in a particular manner. When a cone is cut open along a line running from the base to the apex and flattened, it becomes the sector of a circle.

Azimuthal Projections: In these projections it is imagined that the plane is tangential to the globe at some specific point.

Construction of Projections

Cylindrical Projections: Cylindrical projections can be visualized as made on a cylinder which envelopes the globe and touches it around the equator.

Simple Cylindrical Projection (Cylindrical Equidistant): Let us suppose that a cylinder of tracing paper envelopes the globe touching it along the equator. On this paper cylinder the equator bears the same length as it has on the globe. The equator and other parallels of latitude are projected as circles. This cylinder is afterwards cut along a convenient line parallel to the axis and unfolded into a flat surface. The parallels of latitude become a series of straight lines, all of equal length and parallel to the equator.

Again, along the equator, if the points of intersection of meridians which are evenly spaced, are first pencilled in on the paper cylinder and then opened out, the perpendicular lines drawn through these points will represent meridians of longitude. The meridians of longitude thus derived become a series of parallel straight lines, all of equal length and always spaced evenly, cutting the equator and all the parallels at right angles.

Example : Construct a simple cylindrical projection for the world map showing latitudes and longitudes at intervals of 15°, the radius of the reduced earth being 5 centimetres (Fig. 15).

Construction: The radius of the reduced earth=5 cm.

The formula for finding out the circumference of the earth along the equator is 2 π r where π is equal to 3.1416 or nearly $\frac{22}{7}$ and r is the radius of the reduced earth.

$\because$ The length of the equator $=2\pi r$

$$= 2\times\left(\frac{22}{7}\right)\times 5$$

=31.42 or 31.4 cm. approximately.

Draw a straight line EQ representing the equator equal to 31.42 centimetres. Divide EQ into 24 equal parts. Through these points spaced at equal intervals (15°) along the equator draw meridians as straight lines perpendicular to the equator and let NS be the central meridian. Any meridian, whatever its value, when it stands at the centre of the projection, is called the *central meridian.* Obviously it has nothing to do with the Prime Meridian or the Greenwich Meridian, as such.

To obtain other parallels of latitude at 15° interval, mark off the same intercept distance, as many points as are necessary along NS to the north and south of the equator. Through these points draw lines parallel and equal to the equator. Thus a simple cylindrlical net is produced.

The same result can be obtained by another method:

Describe a circle with centre O and radius equal to 5 centimetres to represent the reduced earth. Let EOE′ be the equatorial diameter. Since the parallels of latitude and meridians of longitude are to be drawn at 15° interval, mark off an angle of 15° from the centre O, and join O to the point obtained to meet the circle at A.

Draw a straight line, 31.4 centimetres in length, to represent the equator showing the range of 360° of longitude. To get an interval of 15° divide it into 24 equal parts. Through these points, spaced at equal inter-

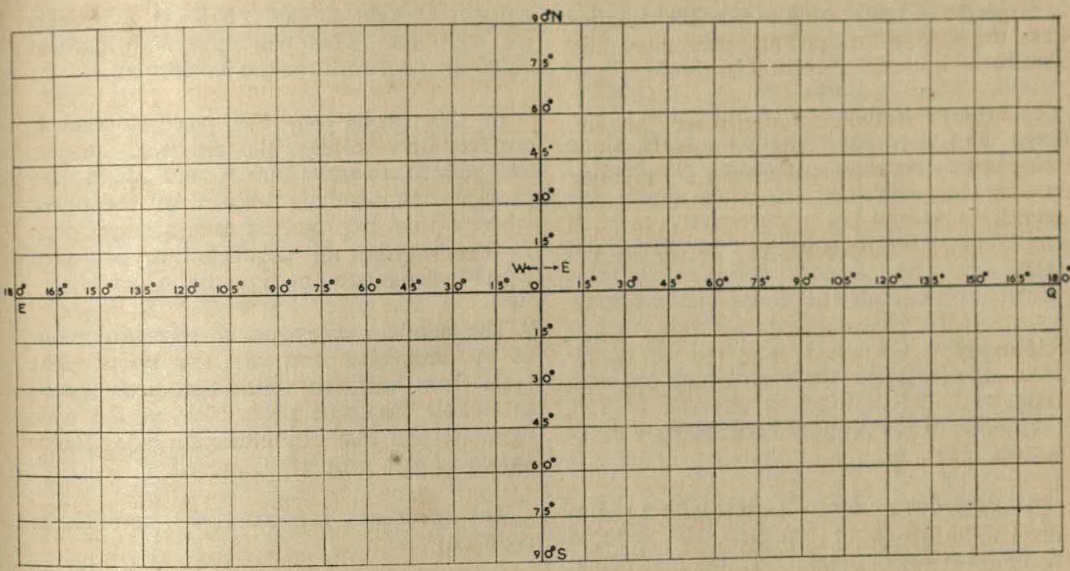

Fig. 15. Simple Cylindrical Projection

It is not an equal area projection since all the parallels are equal to the equator and all the meridians are half of its length. How would you construct this projection by another method discussed in the text?

vals, i.e., at 15° along the equator, draw meridians as straight lines perpendicular to the equator and let NS be the central meridian.

To obtain the other parallels of latitude, mark off starting from the equator distances equal to the length of the arc EA, six times, to the north and south of the equator along NS. Through these points draw lines parallel and equal to the equator. These lines will represent the parallels of latitude, and a network for the world map is produced. Number the parallels and meridians as shown in Fig. 15.

The distance along a parallel of latitude which is measured between two meridians is called the *parallel scale.* This scale varies in different map projections. In the simple cylindrical projection, the parallel scale is correct only along the equator and is exaggerated to the north and south; the exaggeration tending to become infinite towards the poles, where a point is projected as a straight line equal in length to the equator.

The distance along a meridian of longitude which is measured between two parallels of latitude is known as *meridian scale.* This scale also varies with different map projections.

In this particular projection, the meridian scale is correct throughout as the parallels are drawn at true distances. Parallels and meridians cut each other at right angles. Hence a cylindrical equidistant projection is essentially rectangular in shape. All the parallels are equal to the equator and all the meridians are half of the equator in length. Obviously, it is not an equal-area projection.

The projection does not maintain correct shape and hence it is not orthomorphic. Owing to the exaggeration of the parallel scale in the higher latitudes the shape of the continents is highly distorted, and, therefore, the projection is not useful for middle and higher latitudes. They are more suitable for mapping the areas in low latitudes, i.e., equatorial regions.

Cylindrical Equal-Area Projection : Like the simple cylindrical, this projection is also developed by projecting the globe on a cylinder which is tangential at the equator. The cylinder is then spread out flat as a rectangle. In this projection also, the scale along the parallels becomes increasingly exaggerated but at the same time the scale along the meridians diminishes progressively towards the poles. By balancing this horizontal stretching and vertical compression, this projection acquires the equal-area property.

Example: Construct a cylindrical equal-area projection for the world map showing latitudes and longitudes at intervals of 15°, the radius of the reduced earth being 5 centimetres (Fig. 16).

Construction : Draw a circle with a radius of 5 centimetres to represent the reduced earth. Let EOE' and POP' be the planes of the equator and polar axis respectively. Lay off angles at 15° intervals in order to get the latitudes of 15°, 30°, 45°, 60° and 75°.

Produce EOE' to Q making E'Q equal to the true length of the equator, that is $2\pi r$ where $r=5$ cm. Through the points a, b, c, d, e, and P and also a', b', c', d', e', and P' draw lines parallel to the equator. These are the parallels of latitude.

Divide E'Q into 24 equal parts and draw meridians through these points cutting the equator at right angles. MR is the Central meridian. This will give a cylindrical equal-area network for the world map.

In this projection, the parallel scale is correct only along the equator. It gets exaggerated towards north and south, the exaggeration reaching infinity at the poles, where a point is projected as a straight line. In other words, all parallels are projected equal in length to the equator.

The meridian scale is not correct throughout as it diminishes towards the poles. The scale from north to south becomes reduced in exactly the same proportion as the scale from west to east becomes enlarged. Hence the equal-area property is preserved.

The meridians interesect the parallels at right angles.

The area is represented accurately on this projection but it is not an orthomorphic projection. Because of the excessive distortion of shape in high latitudes, this projection is not widely used for maps of the whole globe. The utility of this projection is limited to the representation of countries adjoining the equator. It is sometimes used for world distribution maps.

Mercator's Projection : Mercator's projection belongs to the cylindrical group of projections. It is one of the most famous projections ever devised. It is widely used for

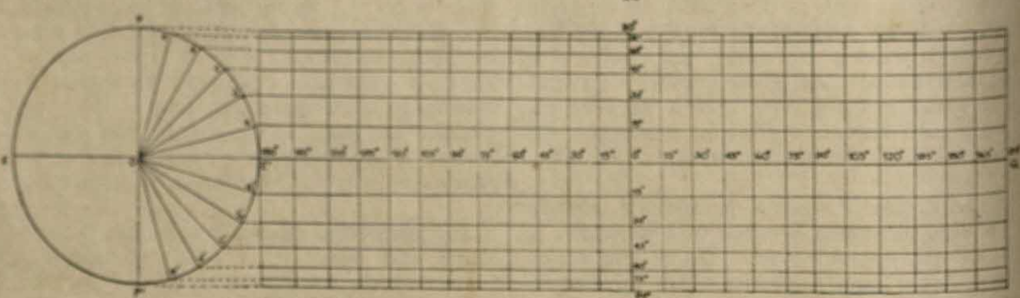

Fig. 16. Cylindrical Equal-Area Projection

In this projection the scale along the meridians decreases in the same ratio as that along the parallels increases. What property does it acquire with this adjustment of scales to make it different from the simple cylindrical projection?

world maps and is invaluable for navigational purposes both on the sea and in the air (Fig. 17).

In this projection, all parallels of latitude are projected equal in length to the equator of the reduced earth. The scale along the equator is, therefore, true, but away from the equator, towards the north and south, it gets exaggerated, the exaggeration being so much that it reaches infinity at the poles. The distances between the parallels of latitude gradually and proportionately increase towards the poles. Hence, the poles cannot be shown in this projection at all, as the exaggeration is infinite.

The meridian scale by construction is exaggerated so that at any point of the map the exaggeration of the meridian scale is exactly equal to the exaggeration of the parallel scale at that point. The meridians are placed evenly, so that their spacing is true to scale on the equator.

Since the exaggeration of the scale along the parallels is accompanied by an equal exaggeration of the scale along the meridians, areas become grossly exaggerated in high latitudes. For this reason, the polar regions cannot be satisfactorily represented. Their appearance becomes misleading. On a Mercator map, Greenland appears to have the

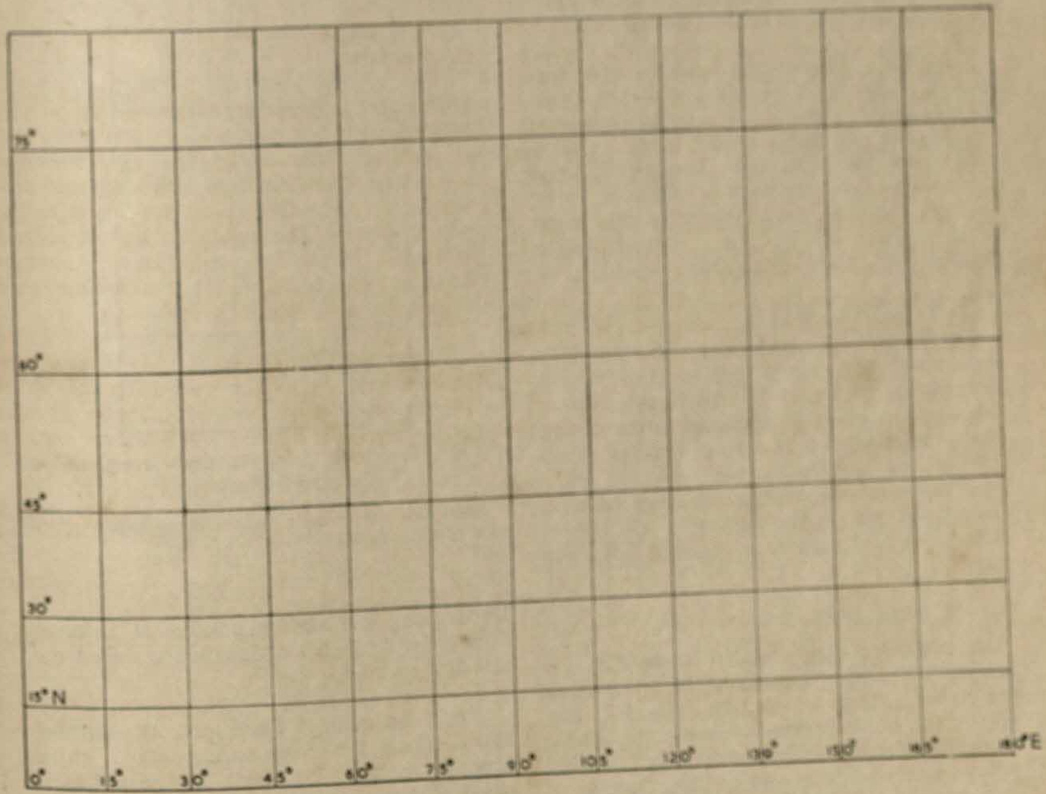

Fig. 17. Mercator's Projection

This projection shows constant bearings because all the meridians and parallels intersect each other at right angles and the parallel and meridian scales maintain a definite ratio. Why is this projection unsuitable for showing correct areas, particularly in high latitudes?

same area as that of South America although it is less than 1/8th the area of South America (Fig. 18).

On the other hand, as each meridian intersects every parallel at right angles, and as the scale ratio is constant throughout, the projection is orthomorphic, that is, although the area of a small square is enlarged considerably, the shape is invariably preserved.

In spite of the disadvantages introduced by the exaggeration in scale, away from the equator, Mercator's Projection will always be of value to navigators and air pilots. This is because a straight line on this projection is a line of constant bearing, that is, it intersects all intermediate meridians at the same angle, and is known as the *Rhumb Line*. Hence the map shows correct directions.

Mercator's Projection acquires this distinctive property of showing constant bearings for two reasons, firstly all the meridians and parallels intersect each other at right angles and secondly, both the parallel and meridian scales maintain a definite ratio. It must, however, be remembered that great circle routes will not be represented as straight lines on a Mercator's Chart.

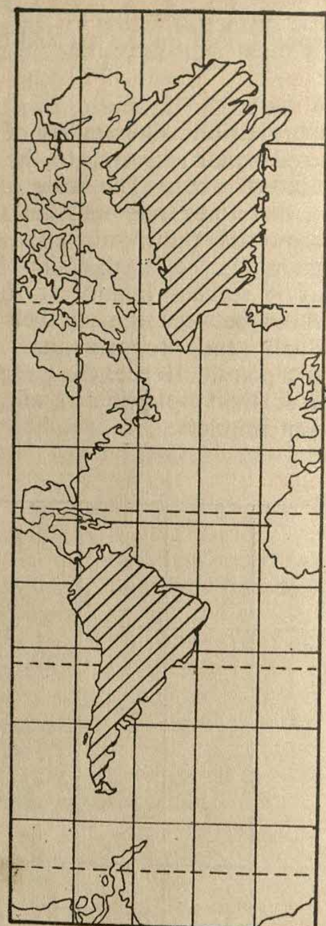

Fig. 18. South America and Greenland on Mercator's Projection

How do you account for the exaggeration of the area of Greenland?

What is a great circle ?

Any section of a sphere by a plane is a circle. When a plane passes through the centre of a sphere, it divides it exactly into halves. The circle so obtained is the largest which can be drawn on a sphere and is, therefore, called a *great circle*. An arc of a great circle is the shortest distance between any two points on the surface of the sphere and hence compares to a straight line on a plane.

Conical Projections

In conical projections the cone may be imagined as either touching or intresecting the globe. Many nets can be devised in this group, the most elementary being the simple conical projection with one standard parallel which is easy to draw and commonly used.

Simple Conical Projection with One Standard Parallel : Suppose a tracing paper cone whose apex is vertically above the pole of the globe, is placed tangential to the globe along any chosen parallel of latitude. This chosen parallel of latitude is called the *standard parallel.*

When the cone is developed, the parallel along which the cone touches the globe becomes an arc of a circle, whose radius is equal to the slant height of the cone, and whose centre will represent the apex of the cone. In the case of the cylinder the standard parallel becomes a straight line, whereas in all conical projections it is projected as an arc of a circle and is made true to scale.

The parallels and the meridians are transferred to the surface of the paper cone and the cone is cut open to make it flat. The meridians on this flat surface will become straight lines radiating from the centre, i.e., the apex of the cone, at uniform angular intervals. The parallels of latitude will now be arcs of circles described about the same centre to which the meridians converge. The meridians will interesect the parallels at right angles.

The standard parallel is made true to scale and all other parallels are spaced at their true distances from the standard parallel to the north and south of it. A central meridian is drawn to represent the meridian which actually runs through the centre of the country to be mapped.

Example: Construct a simple conical projection with one standard parallel at 50°N. for a reduced earth of radius 5 centimetres to show lines of latitude and longitude between 0° to 90° N and 30°E to 130°E at intervals of 10° (Fig. 19).

Construction: The standard parallel is 50°N. The central meridian will be 80°E, that is, midway between 30°E and 130°E.

With O as centre and radius 5 centimetres describe a circle PEP′E′ to represent the reduced earth. Draw EOE to represent the equatorial diameter and POP′ the polar axis. Measure the angles AOE and BOE″ of 50° each to get AB, the standard parallel of 50°N. At A and B draw tangents to meet the produced polar axis at X, the apex of the cone. Now XA or XB is the radius of the 50°N, parallel in the projection.

When this cone is developed, take any line TS as the central meridian, i.e., 80°E. With a radius equal to XA or XB and the centre at T, draw an arc MLK to represent the standard parallel. On the reduced earth PEP′E′, make an angle EOF equal to 10°, the given interval between the parallels of latitude. Hence the distance along the arc EF is the true distance between two parallels at 10° interval. With the distance equal to arc EF, mark off points as many as are

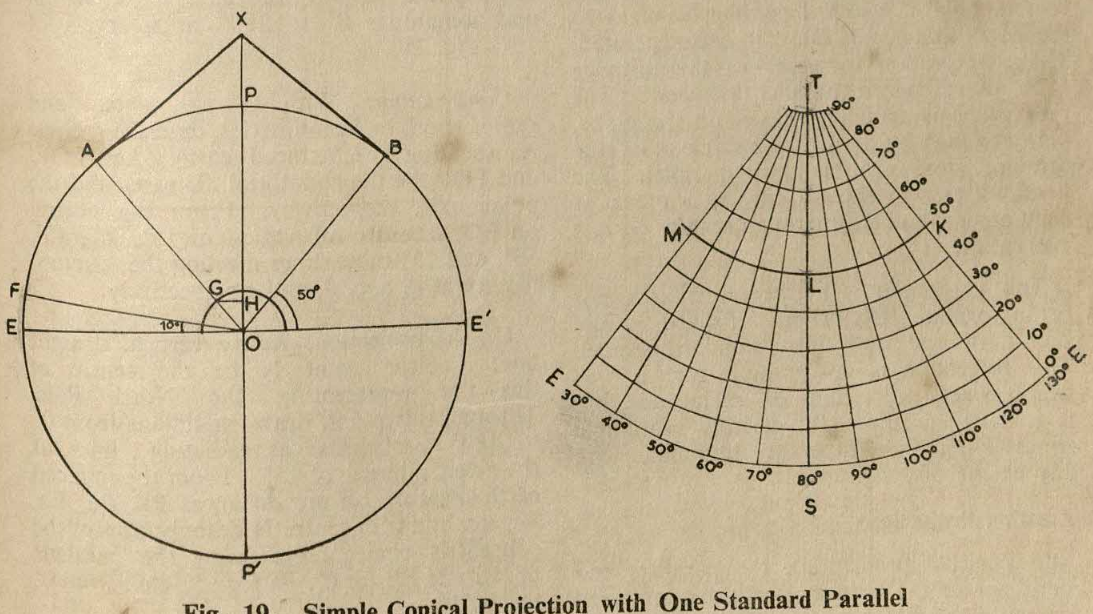

Fig. 19. Simple Conical Projection with One Standard Parallel

This projection is suitable only for narrow latitudinal zones lying in temperate latitudes, but it is accurate for any extent of longitude, large or small. Why does the distortion of shape occur both north and south of the standard parallel?

necessary along the central meridian to the north and south of the standard parallel. In this case you may need to mark off four to the north to show 60°, 70°, 80°, and 90° and five to the south to show 40°, 30°, 20°, 10°, and 0° parallels. With T as centre, draw arcs of circles through these points. These will represent the parallels of latitude from 0° to 90° N.

On EOE′, with O as centre and arc EF as radius, describe a semi-circle. This semi-circle intersects OA at point G. From G drop a perpendicular on the polar axis to meet it at H. Thus GH is the longitudinal distance between two meridians 10° apart on the standard parallel. On the projection, mark off divisions equal to the length of the perpendicular GH to the required number, five on either side, along the standard parallel and on either side of the central meridian. Draw the meridians by joining these points to T. They cut all the parallels at right angles.

This will give a network of parallels of latitude between 0° to 90°N. and meridians of longitude between 30°E to 130°E.

In this projection the parallel scale is correct only along the standard parallel, whereas to the north and south of it, it is exaggerated. The exaggeration increases as the distance from the standard parallel increases. The pole which is actually a point on the globe, is represented by an arc of a circle at its true distance from the standard parallel. The parallels and meridians cut each other at right angles; and the meridian scale is correct everywhere.

This projection is neither equal-area nor orthomorphic. Distortion of shape occurs both north and south of the standard parallel. This projection is not suitable for an area which covers more than 20° of latitude, but it is fairly accurate for narrow latitudinal zones lying in temperate latitudes, with any extent of longitude.

Zenithal Projections

In Zenithal projections, the parallels and meridians of the reduced earth are projected on to a plane which is tangential to the globe. This plane will touch the reduced earth at one point which is the centre of the projection. The simplest cases of these projections are those in which one of the poles is the centre. All zenithals possess the property of maintaining correct azimuths or true bearings from the centre of the projection. Hence, they are also known as *azimuthal projections.*

Zenithal Equidistant Projection : The zenithal equidistant projection is the most useful projection when directions or distances from a particular point are of special interest. In this projection the direction of any point from the centre is true. Likewise, the distance of each point from the centre is also true. In other words, the meridian scale is so adjusted that every point on the projection lies at its correct distance from the centre and, therefore, the projection is said to be equidistant. In this projection when the pole is the centre, meridians are plotted as radii from this point at their true angles apart and the parallels are equidistant concentric circles placed at their true distances apart.

Example : Draw a zenithal equidistant projection for a reduced earth of 5 centimetres for the eastern half of the Northern Hemisphere showing latitudes 0° to 90° N and longitudes 0° to 180° at intervals of 15° (Fig. 20).

Construction: With O as centre and radius equal to 5 centimetres, describe a circle representing the reduced earth. Let EOE′ and POP′ be the equatorial diameter and the polar axis, respectively. From the centre, on EO, measure off angles of 15°, 30°, 45°, 60°, and 75° these lines meeting the circumference at a, b, c, d, and e respectively.

On the projection, draw a vertical straight line. Let the point N be the centre of this line representing the North Pole. Through this point, draw meridians from 0° to 180° eastwards as radiating lines at the given interval of 15°. From the reduced earth measure off arc distances PE, Pa, Pb, Pc, etc. and with centre N describe arcs of the concentric circles representing the parallels of latitude PE for 0°, Pa for 15°, etc., from 0° to 90°N.

The parallel scale is not correct as it increases somewhat rapidly away from the centre. The meridian scale is correct through-

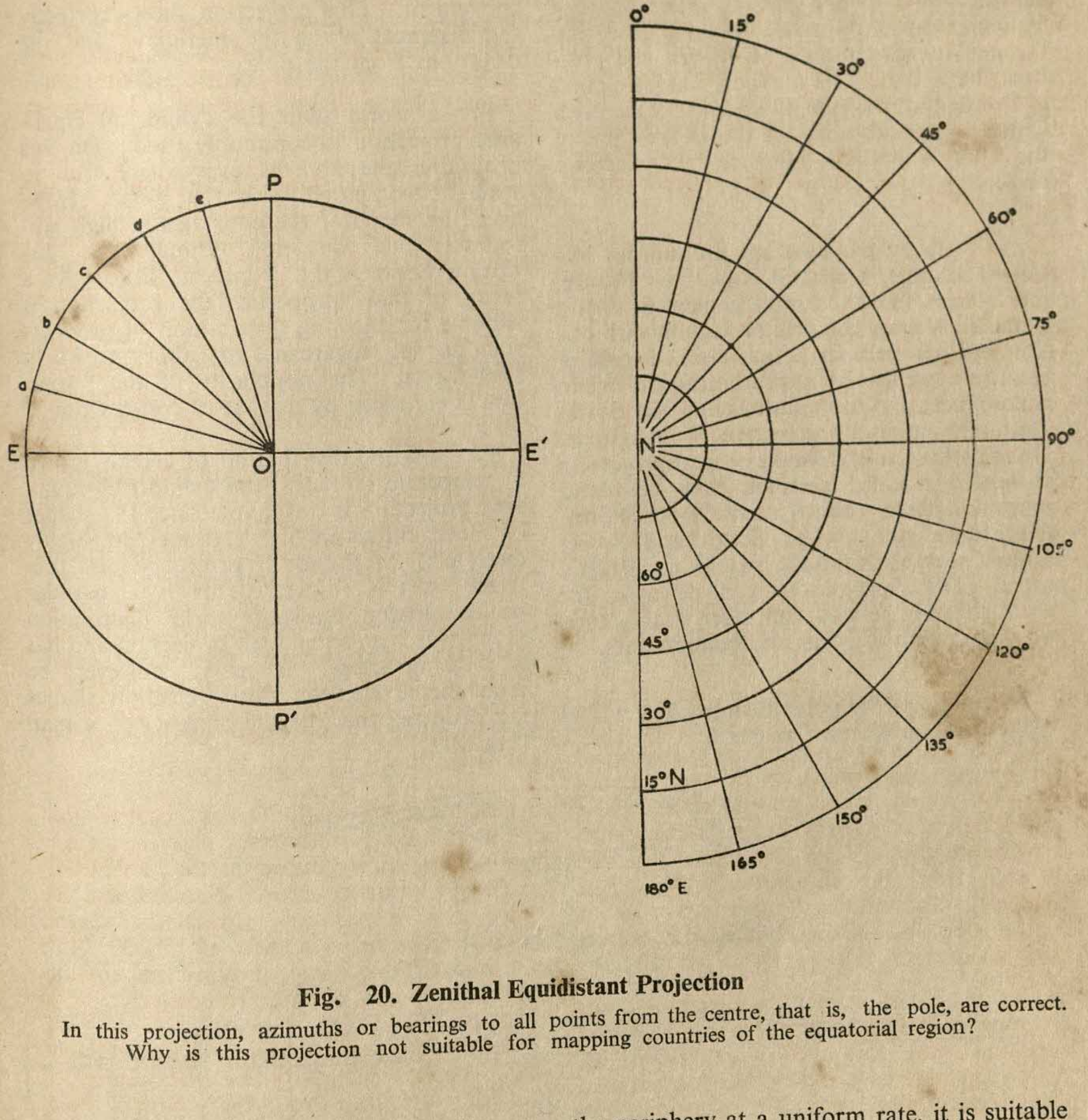

Fig. 20. Zenithal Equidistant Projection

In this projection, azimuths or bearings to all points from the centre, that is, the pole, are correct. Why is this projection not suitable for mapping countries of the equatorial region?

out. Every point is at its true distance and in the right direction from the centre. The projection is neither equal-area nor orthomorphic. This is the most commonly used projection for the polar areas. As the projection creates an exaggeration of scale along the parallels which increases towards the periphery at a uniform rate, it is suitable only for small areas around the pole, not exceeding 30° or so, in latitudinal extent.

Choice of Projections

Selection of a projection of any map

depends upon several factors. The purpose for which the map is to be drawn is obviously the first consideration. Moreover, the position of the area to be mapped, its latitudinal and longitudinal extent, and the ease with which a projection may be drawn are some of the other factors that influence the choice of a projection.

For drawing maps of small countries like Ceylon, Nepal, Cuba, Portugal, or France, a projection like the simple conical is found suitable. A simple conical projection with one standard parallel may be useful in the case of countries like Nepal whose latitudinal extent is not much, and for countries like the Soviet Union which has a vast extent of longitude. On the other hand, a simple conical projection with two standard parallels may be found more suitable for countries like Ceylon, Portugal, France, the United States and Soviet Union whose latitudinal extent is slightly more. These projections can be used for maps showing political units, physical features or distribution of crops and commodities.

For maps of the polar regions the zenithal equidistant projection is perhaps the most convenient. This projection shows correctly the distances along the meridians and the directions from the pole.

For a world map the cylindrical equal-area projection is commonly used. On this projection the area is everywhere true to scale as compared with the globe. However, the shape of the countries in high latitudes is much distorted although the distortion between the tropics is little. As a result of these properties the projection is suitable for showing distribution of products such as rice, sugarcane, or rubber grown in the tropics. The popularity of the projection is enhanced by its ease of construction.

To show the distribution of cereals grown in temperate latitudes, the cylindrical equal-area projection is unsuitable since the shapes of the countries in high latitudes are highly distorted. Mollweide's projection is preferred in this respect. This is a popular projection for drawing world distribution maps as it is an equal-area projection and has a pleasing shape. It may, however, be remembered that on this projection shapes are distorted towards the margins of a map (Fig. 21).

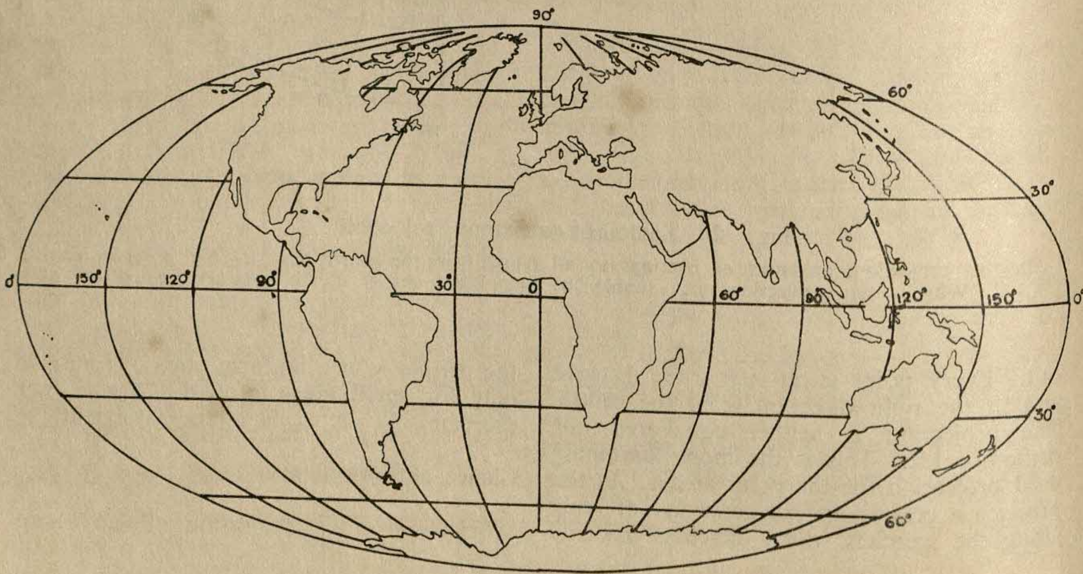

Fig. 21. Mollweide's Projection

This is an equal-area or homolographic projection. The parallels are horizontal straight lines and the meridians, except the central one, are ellipses. How does this graticule differ from that of the cylindrical equal area?

Where we want a correct representation of direction, as in the case of navigation or aviation maps, or in maps showing ocean currents and planetary winds, Mercator's projection is found most suitable.

EXERCISES

Review Questions

1. Answer the following questions :

   (*i*) How does a map differ from the globe?

   (*ii*) What is a map projection?

   (*iii*) Which are the important geographic relationships that one looks for on a map?

   (*iv*) Why is the earth's surface said to be non-developable?

   (*v*) List the basic limitations from which a map may suffer.

2. Write short notes on:

   (*i*) Rhumb Line ; (*ii*) Developable surfaces; (*iii*) Central meridian; (*iv*) Parallel scale; and (*v*) Mollweide's projection.

3. Discuss in brief the need for map projection and the classification of projections according to their use and method of construction.

4. What are the factors that govern the choice of projection? Give specific examples wherever you can.

5. Use one term for each of the following statements :

   (*i*) The network of parallels and meridians.

   (*ii*) An area bounded by two parallels of latitude and meridians of longitude.

   (*iii*) A method of transferring the earth's grid to a plane surface.

   (*iv*) The distance along a meridian of longitude measured between two parallels.

   (*v*) A plane passing through the centre of a sphere dividing it into halves.

6. In the first column are stated important characteristics, one each, of the five different projections. Their names are listed in the other. Make out correct pairs from the two columns:

(*i*) Meridians except the central and the 90th one are ellipses	(*i*) Zenithal equidistant
(*ii*) A projection on which the poles cannot be shown	(*ii*) Cylindrical equal area
(*iii*) A pole is projected as an arc of a circle	(*iii*) Mollweide's
(*iv*) Parallels are equidistant concentric circles	(*iv*) Simple Conical
(*v*) A pole is projected as a straight line	(*v*) Mercator's

7. Given below are the two lists, one for the maps to be drawn and the other for the projections to be used. After going through these lists state what projection you would use for drawing each of these maps. Give reasons for your choice. Do not use the same projection more than once.

(A) Maps to be Drawn :

(*i*) An Antarctic Expedition to the South Pole.

(*ii*) A world map showing ocean currents and the planetary winds.

(*iii*) A map showing world distribution of natural rubber.

(*iv*) A map showing world distribution of wheat.

(*v*) A map showing a railway line connecting the cities of New York and San Francisco.

(B) Projections to be Used :

(*i*) Cylindrical equal-area; (*ii*) Simple conical with one standard parallel; (*iii*) Zenithal equidistant ; (*iv*) Mercator's; (*v*) Molleweide's

Finding Out

Consult a couple of atlases to find out what projections are used for different types of maps. List the names of projections not discussed in this chapter. See if you can compare them with the projections you already know.

Problem to be Solved

There are two globes in a school. Their radii are 10 cm. and 5 inches respectively. Find out the approximate scale of each of these globes in kilometres to a centimetre and also in miles to an inch.

Constructional Work

Construct yourself the following projections as explained in the text:

(*i*) Simple cylindrical projection

(*ii*) Cylindrical equal-area projection

(*iii*) Simple conical projection with one standard parallel, and

(*iv*) Zenithal equidistant projection

Perhaps you may like to change the scale or the specifications given in the examples.

Films Available

(1) Introduction to Map Projection. No 526.8; 21 mins; English; D.A.V.E.

(2) The Impossible Map. 10 Mins ; English; C. H. C.

(3) Global Concepts in Maps. No. 912; 10 mins; English; D.A.V.E.

Further Readings

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CHAPTER 4

Graphical Representation of Geographical Data

A GEOGRAPHER is required to represent various kinds of data on a map. On the basis of their data and contents, maps are classified as relief maps, climatic maps, distribution maps and so on.

RELIEF MAPS

The surface of the earth is a patchwork of mountains, valleys, plains and seas. These elevations and depressions of the earth's surface are technically known as the *relief* of the earth. This relief is best represented by models but they are expensive and cumbersome to handle. Moreover, their vertical scale is considerably exaggerated as compared to the horizontal scale.

Methods of Showing Relief : The map maker is confronted with the task of presenting the uneven or the undulating surface of the earth on a flat sheet. A *relief map* depicts the elevation of the land above sea level on a flat surface. Various methods are employed to show such relief on maps. These are : contours, formlines, layer colouring, hill-shading, and hachures. Sometines a combination of methods is adopted : for example, contours and hachures, contours and hill-shading.

Contours : A contour is an imaginary line (drawn on maps) joining the points having the same elevation above mean sea level. In other words, a contour is a line of constant elevation or equal altitude above sea level. The method of showing relief through contours is perhaps the most accurate, common and popular. This method is most useful for presenting with great precision relief features, with their exact form and elevation. It is particularly useful if the region is rather limited and is to be studied carefully in all its details.

Contours, sometimes called *contour-lines,* are drawn on the basis of actual survey conducted in the field. A map showing the configuration of a surface by means of contours is called a *contour map* (Fig. 22).

Contours are drawn at different levels, say 20, 50 or 100 metres or 50, 100, or 200 feet, above mean sea level. The interval between two successive contours is called the *vertical interval* and is usually written as V. I. The vertical interval is usually constant on a given map and is given in metres or feet. While the vertical interval between two contours remains constant, the horizontal distance between the two varies from place to to place depending upon the nature of the slope. This horizontal distance is known as the *horizontal equivalent* and is usually written as H. E. It is generally stated in metres or yards. H. E. is greater for gentler slopes and lesser for the steeper.

Sometimes broken lines running in the direction of contours are used in addition to contour lines to represent particularly the hilly or mountainous country. These are called *form-lines.* They are not as accurate as contours, and are based on observation

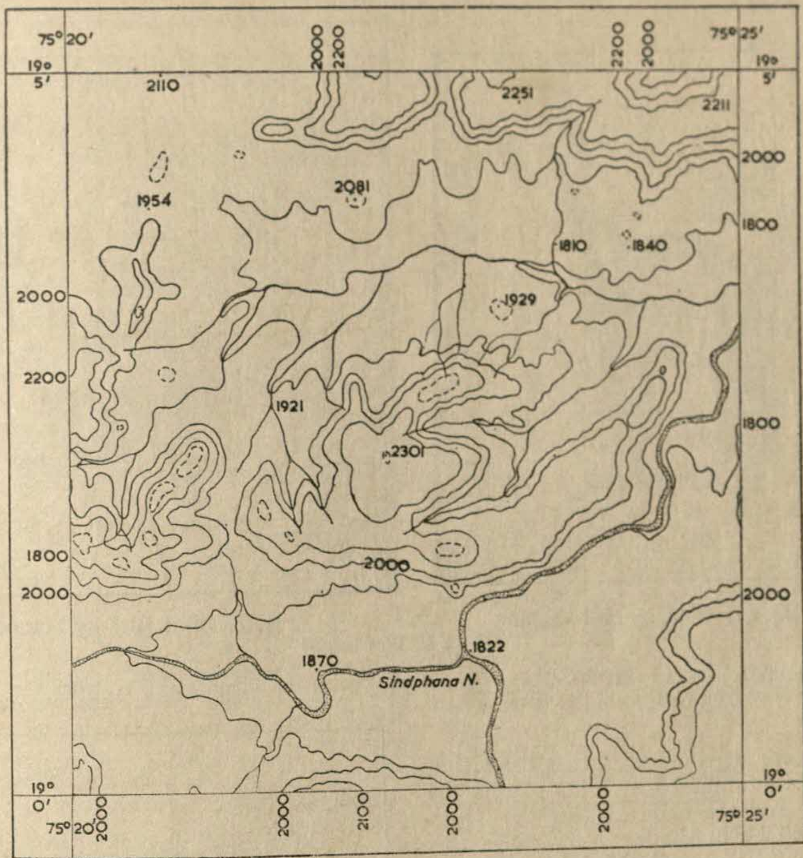

Fig. 22. A Contour Map

A contour-line is often called a "level line" since it joins places of constant elevation. Each contour-line on this map would look like the shore line if the sea rose to the elevation represented by that contour. How do form-lines differ from contours?

only without any precise measurements. These help to indicate minor details which cannot be easily shown by contour lines especially when the contour interval is large, as is usually the case with the maps representing mountainous topography.

Layer Colouring: This is a very common method of showing distribution of relief over a wide area. Usually a map of a country or a continent is shown in colours. Atlas and wall maps follow this method almost universally.

The colour scheme adopted in showing relief or elevation is almost uniformly followed everywhere. The sea is coloured blue. Usually deep blue indicates deep sea and light blue stands for shallow waters. Low-lying areas are shown in deep green and as the land rises in elevation, light green, light brown, dark brown, crimson, red and white are used in this ascending order.

A key is provided to explain the exact height represented by each colour. The method is useful in giving a generalized picture of the relief of a large region.

Hill-shading: In this method the relief of the region is shown on the map by shading only those slopes which face south and east.

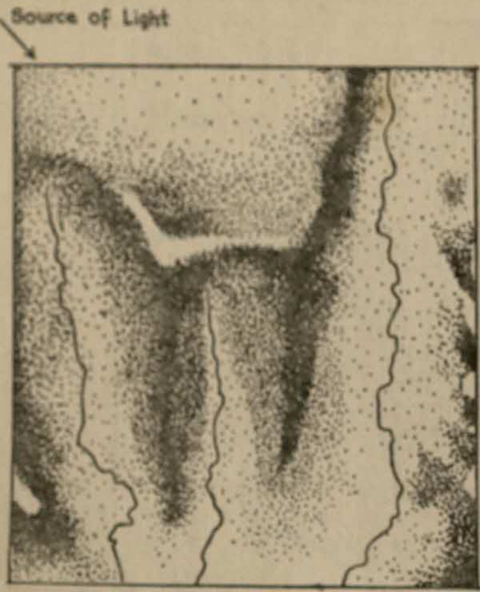

Fig. 23. (a) Relief by Hill-shading

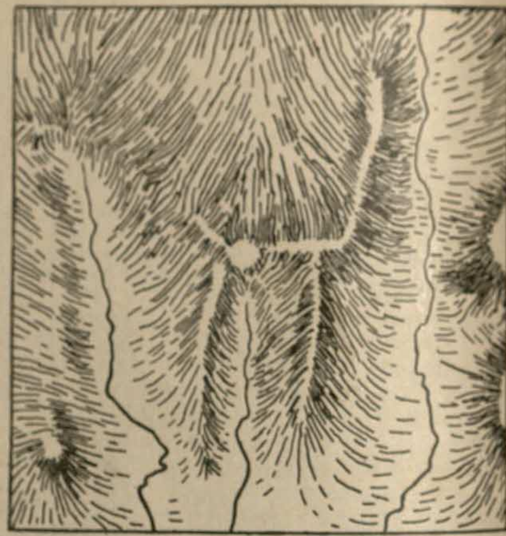

Fig. 23 (b) Relief by Hachures

(After H. W. Martin)

Slopes facing south and east are shaded heavily, presuming the illumination is from the north-west. Which method do you think is more effective?

In other words, it is assumed that the region concerned is illuminated by a lamp from the north-west, and the region facing the south and east will be in shade. Very often, this method is used in association with contours (Fig. 23 (a) and (b)).

Hachures: Hachures are small straight lines drawn on a map to give an idea about the differences in the slope of the ground. They are lines drawn along the direction of maximum slope. Hachures are drawn from the highest point of a hill or a ridge to its bottom and are perpendicular to the contours. They are made thick and put close together when the slope is steep and thinner and farther apart when the slope is gentle (Fig. 24).

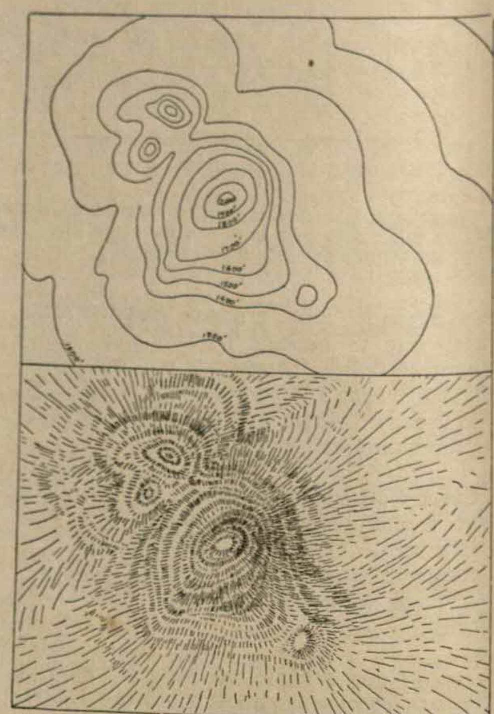

Fig. 24. Relief by Contours and Hachures

Hachures give an idea of the relative steepness of slopes, but they do not indicate absolute heights. In a hilly country, closely set hachures obscure details of topography. What advantage do contours have over hachures?

On such a map the darkest portions represent steep escarpments, and lighter shades stand for gentler slopes. The blanks show plateaus, tablelands, hilltops and flat valley bottoms.

Hachures give a fairly good idea of the configuration of land but do not indicate actual heights.

Interpolation of Contours

Before one knows how the contours are drawn on a map, one has to understand spot heights and bench marks. Surveyors find out the exact height of the ground surface above sea level at a few spots with the help of surveying instruments. The heights, thus found out in the field and plotted at the corresponding points on the map, are known as *spot heights*. The spot height is shown on a map by a dot followed by a number giving the height in metres, or in feet.

Many a time, the heights of specific points on prominent and durable material objects like rocks or buildings in the field are recorded for the sake of permanent reference. These heights are determined instrumentally with great accuracy and recorded up to one decimal point in metres or in feet. These are known as *bench marks*. On the map a bench mark is indicated by the letters B.M., followed by the number giving the actual elevation of the mark above mean sea level. Bench marks thus give the exact elevation of the mark and not that of the ground. They are highly useful for field workers since these readily serve as points of reference for determining the heights of other places. Bench marks thus add to the utility of a map.

The interpolation of contours becomes possible once the spot heights of a few places in the field are plotted at their corresponding points on the map. First of all, one has to study carefully the highest and the lowest spot heights plotted on the map and to find out the range of elevation. This leads to the next step of determining the contour interval which has to be uniform and suitable for the purpose. Usually it is taken in round figures such as 20, 50, or 100 metres, depending upon the total range of elevation (Fig. 25).

In this case since the range of elevation is 520 metres, it may be convenient to choose the contour interval of 100 metres which is a round figure. Now start with the lowest contour-line which in this case will be 1,200 metres. The contour-line will have to pass through a belt that would be bounded by 1,100 metres on one side and 1,300 metres on the other. The exact course of the contour-line will be determined by the spot heights ranging between 1,100 metres and 1,300 metres, assuming that the slope from one spot height to the other is uniform. Therefore, the contour of 1,200 metres while passing through two respective spot heights of 1,150 metres and 1,250 metres will be just midway between the two points. Again while passing through 1,130 metres and 1,210 metres it is clear that it will be closer to the latter. To be exact, the distance between these two spot heights will be divided into eight equal parts and the contour will be drawn seven units away from the 1,130 metres spot height and only one unit away from the 1,210 metres mark. Now you can draw for yourselves the contours from the rest of the spot heights.

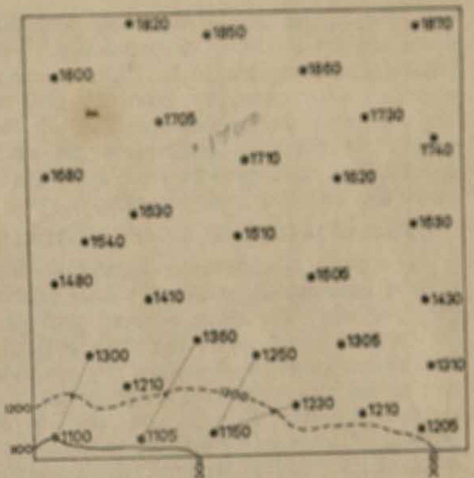

Fig. 25. Interpolation of Contours

Within the belt of one contour interval the exact course of a contour is determined by spot heights, assuming that the slope from one spot height to the other is uniform. Between what spot heights would the contour-line of 1,700 metres pass on this map?

While drawing contours on the map a few things must be kept in mind. Contours neither start nor end abruptly in a given area. On a map they either run from margin to margin or form closed patterns. Contours of different values do not cross each other.

However, in the case of waterfalls and cliffs where the cut is almost perpendicular to the ground they may merge to form a single contour. Care must be taken to give the contour value on the line itself, or on that side of the line that is towards the rising ground. Its value must be given at the points where they cut the margin of a map.

REPRESENTATION OF RELIEF FEATURES

The spacing of contours is significant to us since it indicates the gradient. The contours are close when the slope is steep and they are farther apart when the slope is gentle. The closed patterns developed by contours give us an idea about the shape or form of various physical features on the earth's surface. It may be of interest to know how some of the physical features are represented by typical contour patterns.

A Conical Hill : A conical hill rises almost uniformly from the surrounding land. A volcanic cone is a typical example of such a hill. A conical hill with uniform slope is represented by concentric contours spaced almost regularly (Fig. 26).

A Plateau : A flat-topped high land rising above the adjoining plain is called a plateau. In the representation of a plateau the contrast between the closely spaced contours of the marginal slopes and their absence or wide spacing on the plateau surface is well-marked (Fig. 27).

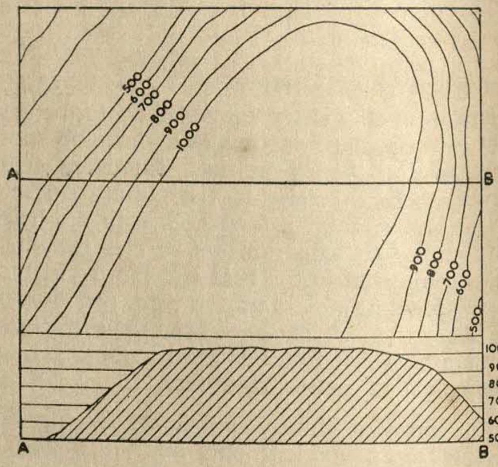

Fig. 27. A Plateau

The top of a plateau is more or less flat and is represented by very few contours, whereas its sides are often steep and are shown by closely spaced contours on a map. What will be the shape of contours if the sides of a plateau are eroded by numerous streams?

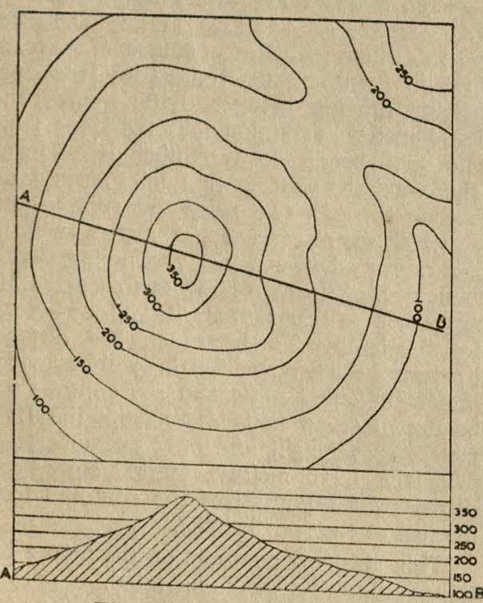

Fig. 26. A Conical Hill

Concentric contours spaced almost evenly on a map represent a conical hill. How does the spacing of contours of a conical hill differ from that of a flat-topped hill?

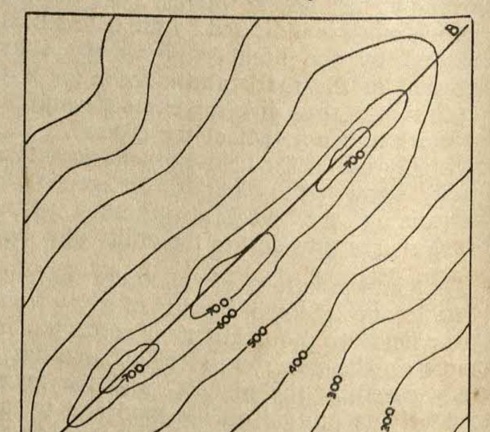

Fig. 28. A Ridge

Contours forming elliptical shapes and very often enclosing isolated peaks represent a ridge on a map. How does a ridge on a map differ from a plateau?

A Ridge: A ridge is a high elongated hill or a chain of hills forming a long narrow strip of high land very often with sharp edges. It is represented on a map by contours of more or less elliptical shape (Fig. 28).

A Plain with a Knoll: A knoll is a low detached hill and is usually round. Very often, plains contain such knolls, here and there. Small enlcosed contours, usually circular in shape, represent knolls, whereas the well-spaced contours, or their absence over the rest of the region, indicates a plain (Fig. 29).

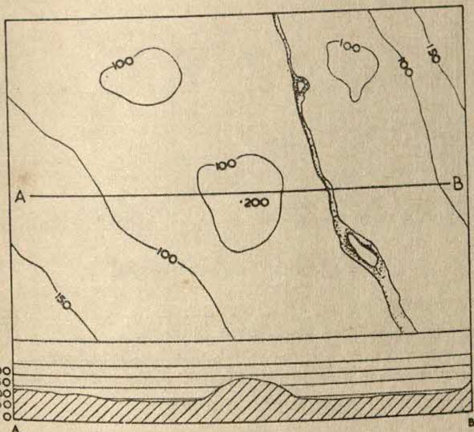

Fig. 29. A Plain with a Knoll

Small circular contours represent a knoll, whereas widely spaced contours indicate a plain on a map. What kind of topography does a map suggest when contours are practically absent?

A Valley: A valley is a lowlying area of land between two hills or ridges often occupied by a river.

A valley is generally represented by V-shaped contours. The contours recede from the low land and press back into the hills or the higher land. Thus the apex of 'V' point to the higher ground and its arms to the lower, that is, contours tongue up the valley (Fig. 30).

A Spur: A spur is a tongue of land, as it were, projecting from higher ground into the lower. It is also represented by V-shaped contours but in the reverse manner. The arms of 'V' point to the higher ground and the apex of 'V' to the lower (Fig. 31).

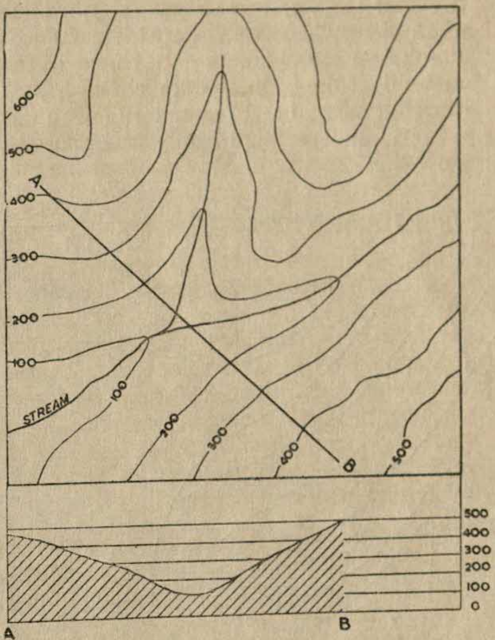

Fig. 30. A Valley

The arms of 'V' are close together in steep valleys and wide apart in gently sloping valleys. Which of the two valleys in this map is steeper?

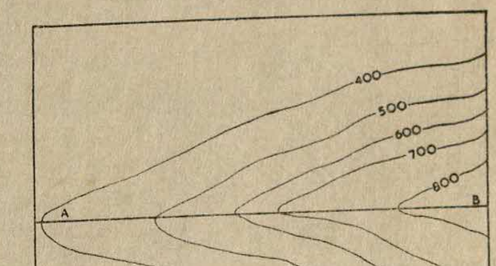

Fig. 31. A Spur

A spur is the extension of high land towards the low land. What distinguishes a valley from a spur on a map?

A Cliff : A cliff is a very steep or almost perpendicular face of rock with a considerable height overlooking a lake, a river, a sea or a plain. On a map, a cliff may be identified when the contours run very close to one another ultimately merging into one (Fig. 32).

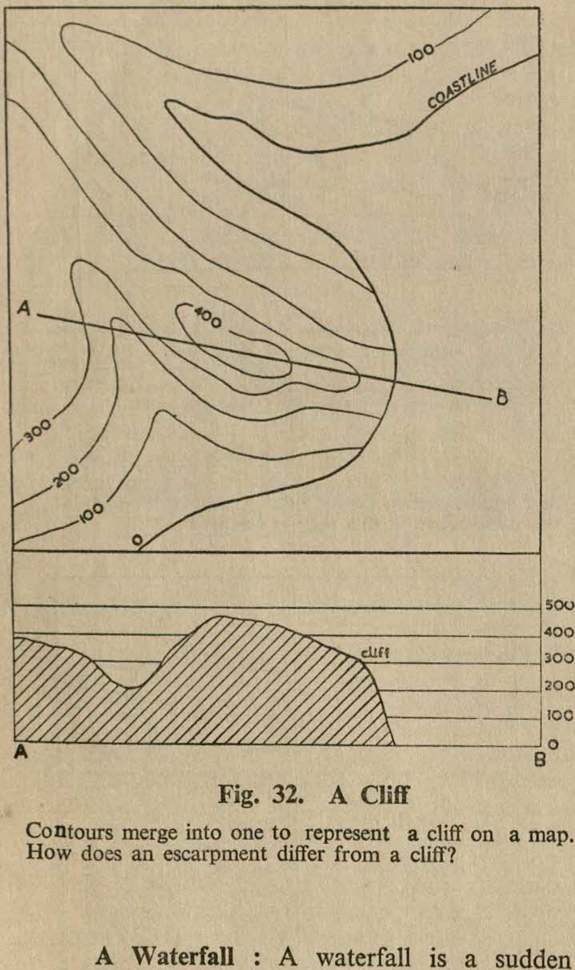

Fig. 32. A Cliff

Contours merge into one to represent a cliff on a map. How does an escarpment differ from a cliff?

A Waterfall : A waterfall is a sudden and more or less perpendicular descent of water over a step of considerable height in the bed of a river. On a map, a waterfall can be identified when contours merge into one while crossing a river stream (Fig. 33).

Types of Slopes

When contours are evenly spaced on a map

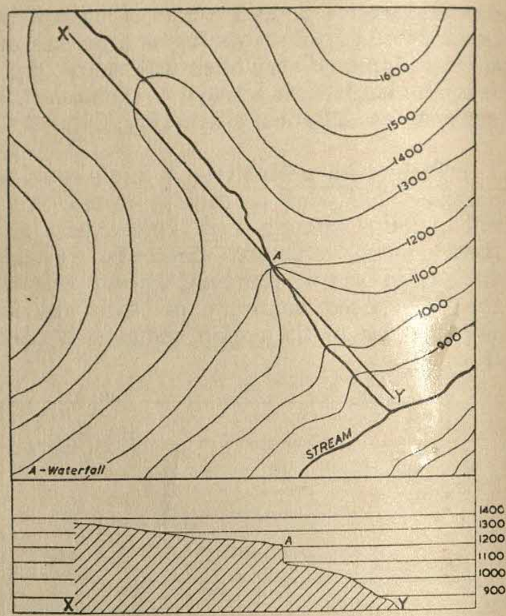

Fig. 33. A Waterfall

When contours cross a stream and are spaced closely together they indicate occurrence of rapids. When contours touch each other or merge into one, they form a precipitous fall. What is the difference between a waterfall and a rapid?

the slope will be uniform. Such a uniform slope is a rare phenomenon. Very often we see that a hill slope is such that the contours are closer either at the top or along the foot of a hill. When the contours are closer at the foot as compared to those at the top, the slope is said to be *convex*. The knowledge of these contour formations is important from the tactical point of view.

In the case of the convex slope of a hill, persons A and B standing at the top and the bottom respectively will not be able to see each other. This is due to the intervening ground that intercepts their sight.

When the contours at the top of a hill are close as compared to those at the bottom the slope is said to be *concave*. In such a case persons standing at positions A and B will be able to see each other as no ground intercepts their line of sight (Fig. 34).

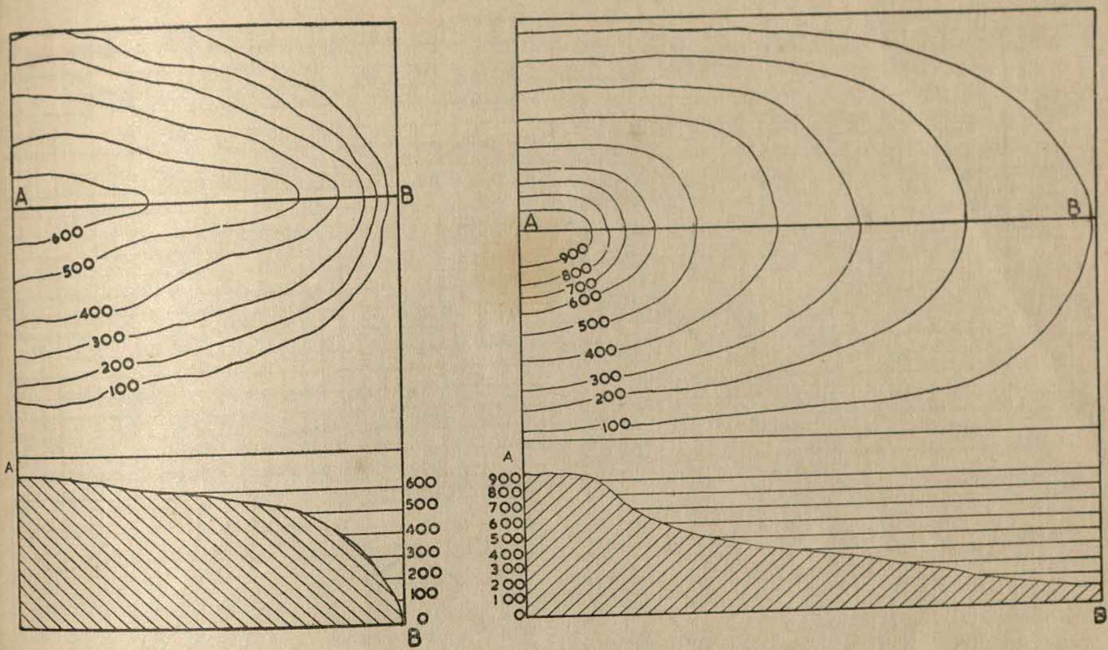

Fig. 34. Convex and Concave Slopes

A convex slope prevents a direct view, whereas a concave slope gives an uninterrupted view. How does a cross-section help in visualizing the type of slope?

DRAWING OF A CROSS-SECTION

A contoured map gives us a fairly good idea about the nature of the terrain. In order to visualize the nature of the landscape depicted on the map it may be useful to draw cross-sections along a few lines.

If along a certain straight line a portion of the ground is cut vertically, the side view of the cut forms a *cross-section.* It is also called a *section* or a *profile.* A railway-cutting is a kind of profile, provided the railway line is perfectly level and straight.

A cross-section thus gives us an exact idea of heights, slopes and depressions along a given line; but they help us in visualizing more vividly the configuration of the surface.

For drawing a section, take any two points A and B on the map. Join them to form a straight line AB. Take a graph paper with a straight edge and place it along AB. Make pencil marks on the edge of the paper at points wherever it cuts contour lines. Note carefully the height of each contour line against each pencil mark. Draw perpendicular lines on this line AB from each of the pencil marks. After choosing a suitable scale, say 1 centimetre for 100 metres, mark the height of each perpendicular line to represent the height of the corresponding contour line. Now by joining the tops of these perpendiculars with a smooth continuous line you get the required cross-section or a profile. It must be remembered that in such cross-sections the vertical scale is very much exaggerated in comparison to the horizontal scale (Fig. 35).

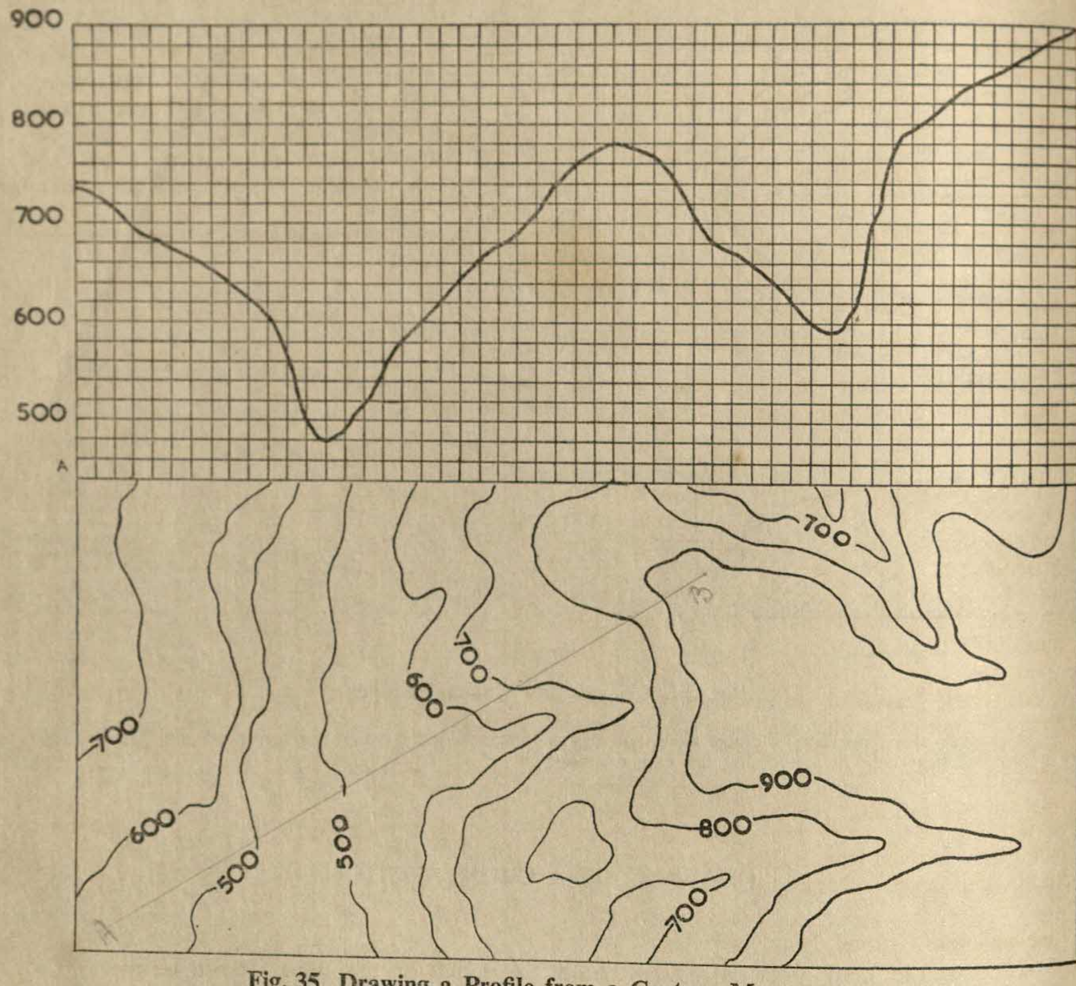

Fig. 35. Drawing a Profile from a Contour Map

Giving an idea of heights, slopes and depressions along a given line, a cross-section helps us in visualizing the relief. In what respects is a cross-section inaccurate?

CLIMATIC MAPS

In climatic maps, the distribution of data is shown by lines of equal value, viz., isotherms, isobars and isohyets. The places where observations are taken are first plotted on the map and the actual amount of rainfall, temperature or pressure is indicated against each station of observation. Then, as in the case of contours, lines are drawn with a definite vertical interval between them. This interval remains constant throughout the given map. Thus lines are drawn on a map to show equal amount of temperature, pressure and rainfall. Lines connecting places of equal temperature are called *isotherms;* lines of equal barometric pressure *isobars;* and lines of equal rainfall *isohyets.*

The spacing of these lines, i.e., the distance between them, represents the rate of variation. If the lines are much apart, the variation is gentle and where they are closely set, the variation becomes sharp.

Each line is numbered according to its respective value. The numbering is always done on the upper side of the lines and the values are so written that they come one above or below the other, in the ascending or

descending order. The number are never placed haphazardly. For the preparation of climatic maps detailed statistical information is needed.

As both temperature and pressure vary with altitude, they are generally reduced to sea level to make these readings comparable and then only are isothermal and isobaric maps drawn. The isohyet maps are, however, directly prepared from the figures available, that is, no reduction to sea level is done.

Isotherms, isobars and isohyets do not necessarily follow the contour-lines. They are very seldom straight lines. Like contours they never intersect each other. On a map, either they are shown complete, more or less circular in form, or their ends reach the edges of the map. In reality the gradient of temperature, pressure, or rainfall is never uniform as is suggested by the map. There is always a transition zone, which these lines fail to indicate.

At times graphical representation is preferred for showing the variation of temperature, pressure, rainfall, and wind velocity according to the time factor, viz., a day, a month, or a year. These graphical representations when used in combination with isotherms, isobars and isohyets make the climatic map more meaningful.

Line and Bar Graphs

Line graph involves the drawing of a continuous smooth line through a series of points which are determined by means of two coordinates. The line joining the points is referred to as a curve. In this graph, change in one variable is shown with reference to another. One of the variables is usually time, viz., days, months, or years. It is customary to show time on the X-axis, i.e., the horizontal scale and the amounts of temperature, rainfall and pressure are plotted along the Y-axis, i.e., the vertical scale. The choice of the vertical scale should be such that the curve should not show too sharp a variation (Fig. 36).

Sometimes the temperature curve and the rainfall line are plotted on the same graph. In this case, the temperature is reckoned on one side of the vertical scale and the rainfall on the other. When two or more temperature curves are plotted on the same graph for purposes of comparison, care should be taken to prevent confusion. Some distinction is made in the nature of the lines. For one graph the line can be continuous, for another discontinuous and for a third dotted.

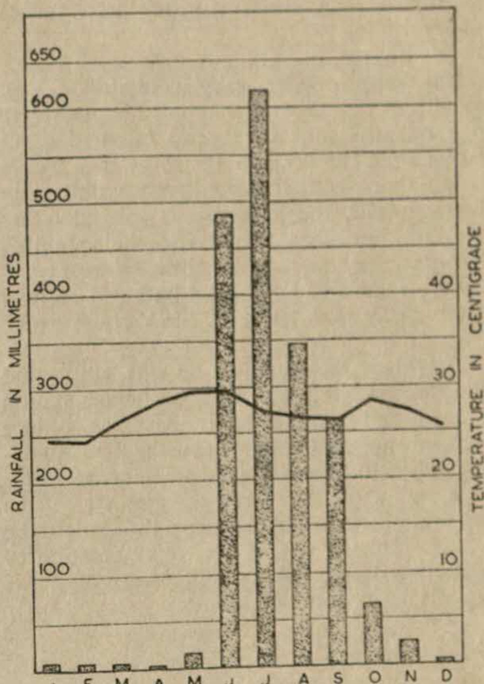

Fig. 36. A Line and a Bar Graph

In the figure mean monthly temperatures are shown by a line graph, whereas average monthly rainfall is represented by bars. This climatic data is for Bombay station. What information do you gather from this graph regarding the maximum and minimum mean monthly temperatures and the dry and wet seasons at Bombay?

The seasonal character of temperature and rainfall are important aspects of climate in relation to crop production and such graphs, therefore, are of great use.

Bar graph consists of a series of columns or bars which are proportional in length to the quantities they represent on a selected scale. The exact length of each bar is computed and parallel lines are drawn after the scale of value has been determined (Fig. 36).

These bars are of equal width and care is taken not to make them too wide. It is always preferable to leave a space slightly less wide than the bar itself between two successive bars. In some particular cases like rainfall bar graphs, there is no need for leaving any intervening space. Hence, rainfall bar graphs are often described as 'battleship diagrams' owing to the shape of their profile.

Bar graphs offer easy comparison of quantities but they are not satisfactory where one quantity may be several hundred times larger than the other, since some bars would be so short as to become barely visible. In these graphs, the bars can be placed either vertically or horizontally except in rainfall bar graphs where they are always shown vertically. Labels of horizontal bars can be read more easily than those of the vertical bars.

At times, the temperature line graph and the rainfall bar graph of a particular station are plotted on the same base-line. Since temperature and rainfall are the two fundamental features of climate, such a representation will show the general character of the climate of that particular place throughout the year. This is why in the representation of climatic data, the combination of these graphs is in common use.

Wind Rose

The wind rose is a diagram particularly suited to show the frequency and direction of wind at any place at a certain time. This diagram is also known as the 'direction diagram' as it indicates the direction of wind.

The usual method of constructing such a diagram is to draw eight radiating lines evenly spaced around a common centre representing the eight directions—N, NW, W, SW, S, SE, E, and NE. Each ray of the wind rose denotes the number of days the wind blows from the corresponding direction. The length of each ray is proportional to the quantity it represents on a selected scale. The number of days when the wind is calm is shown by a small circle, the number being entered into it. These wind roses are commonly shown on climatic maps and pilot charts.

Fig. 37 illustrates the wind roses of Madras and Delhi respectively and can be drawn in either way, as shown below.

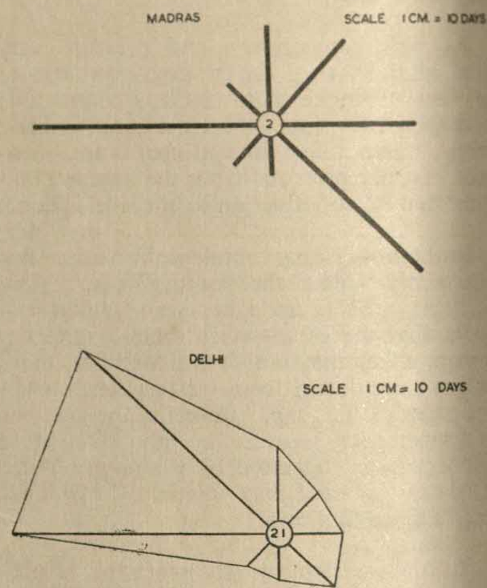

Fig. 37. Two Types of Wind Roses

These diagrams are for Madras and Delhi respectively. A wind rose or a direction diagram is also known as a 'star diagram' because of its star-like appearance. Which winds are predominant at these two stations?

Station	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm
Madras	36	41	55	79	19	20	91	22	2
Delhi	33	22	24	29	17	16	102	101	21

Distribution Maps and Diagrams

For students of geography, distribution maps and diagrams are very useful. Statistical data when presented through maps and diagrams become more meaningful as compared to the tables of these data. These maps and diagrams make it easy to find out, almost at a glance, the location and distribution of various economic activities and phenomena. They help us to make regional comparisons. The regional variations vividly brought out by these maps and diagrams induce the readers to reason out various geographic and other factors responsible for the peculiarities of the distribution.

There are various methods of representing statistical data pertaining to distribution. These are : (*i*) pictorial representation, (*ii*) simple and compound bar diagrams, (*iii*) pie or wheel diagrams, (*iv*) dot method, and (*v*) shading method.

Pictorial Diagrams

Statistical data may be represented effectively by pictorial symbols such as loaded bags to denote cereal, sugar, or cement production, barrels for oil and bales for cotton. These pictorial representations are symbolic of the quantities they represent. For example, data relating to automobiles may be represented by a symbol of an automobile; animal population by a corresponding animal symbol. In every case each symbol is taken to represent a certain number of units (Fig. 38).

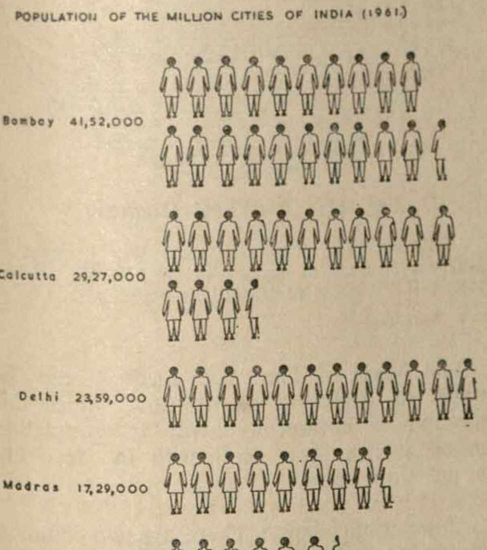

Fig. 38. A Pictorial Diagram

This diagram shows the population of the million cities of India. What advantage does this diagram possess over line and bar diagrams?

In this figure each symbol of a person represents a population of 2 lakhs. Therefore, for Delhi 13 persons represent 26 lakhs. The diagram thus gives the correct idea about the population of the leading cities of India and the relative position of each city.

Line and Bar Diagram

Besides representing climatic figures, line graphs are also used for showing statistical data. These graphs involve the drawing of smooth curved lines through points determined by two co-ordinates. They show absolute or percentage values of agricultural production, yield per acre, industrial output, per capita income, trade statistics and so on, over a given period of time. These graphs are known for their accuracy and exactness.

A bar diagram is a simple and handy device to represent statistical quantities. Bar diagrams are of two types : the simple and the compound. The bars are drawn as columns with a uniform width. Their length varies in proportion to the quantities to be represented. Bars can be drawn either horizontally or vertically.

Simple bars generally are easy to draw as they do not involve much calculation. Each bar represents one quantity. Only the length of each column is determined by the uniform scale to be adopted for the whole diagram. The scale would depend upon the range of the data and the maximum length of the bar that can actually be shown on a given piece of paper. For example, the largest production of rice is 85 million tons in China and the least production is 7.4 million tons in Burma. If we want to restrict the maximum length of the diagram to 6 centimetres we can choose the scale as 1 centimetre to 15 million tons of rice (Fig. 39).

Compound bars are generally used to show the overall quantities as well as its subclassification into constituent units. For example, the figure shows the land use pattern in the Punjab plains for 1960-61. The compound bar indicates not only the total land under use but also its further classifications under different categories. Obviously

the scale is the same for showing the total length of the bar as well as its sub-divisions (Fig. 40).

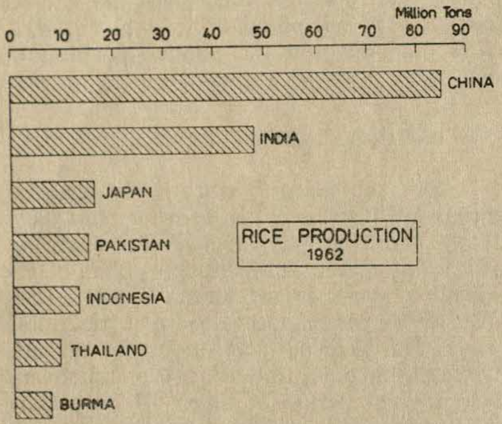

Fig. 39. A Simple Bar Graph

This diagram shows the production of rice in some of the leading countries. How would you determine the scale for drawing such a diagram?

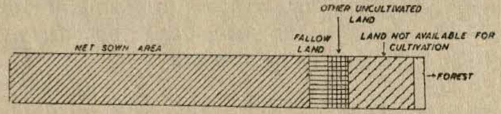

Fig. 40. A Compound Bar

The diagram shows the land use pattern in the Punjab plains for 1960-61. The scale is the same for showing the total land under use and its sub-divisions. How is a compound bar an improvement over a simple bar?

Wheel Diagrams

Circular diagrams are often referred to as *wheel diagrams* or *pie diagrams*. A circle divided into sectors is another way of showing how a given total is made up of individual items. It simplifies the choice of scale for a diagram in which individual statistics are to be expressed as percentages of the total.

For example, to illustrate it for irrigation in India, the circle is supposed to represent the total area irrigated by different sources during 1958–59. The area under each source is calculated as percentage of the total irrigated area. Then it is converted into angles at the ratio of 1 : 3.6 since a circle consists of 360°. The angle of each sector representing each sub-division of the total irrigated area is named, coloured or shaded separately, giving a clear idea of the relative importance of each source of irrigation (Fig. 41).

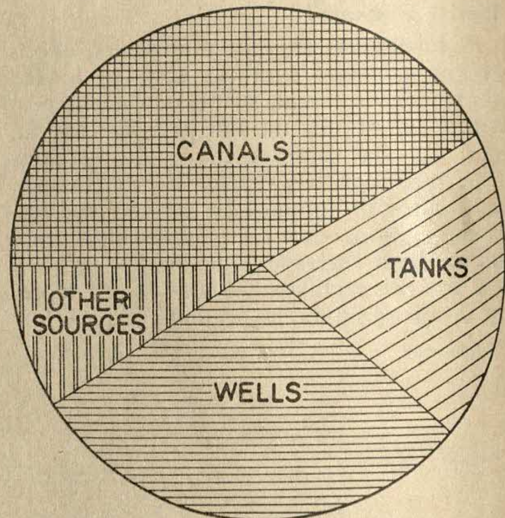

Fig. 41. A Wheel Diagram

This diagram shows the total area irrigated by different sources in India during 1958-59. Which source is the most important in our country?

Dot Maps : The dot method can be used for depicting distribution. Since this method is commonly used in population maps, it has been dealt with in detail in population maps.

Population Maps : There are two common methods by which population maps are drawn. They are the dot method and the shading method.

Dot Method : When used in diagrams, dots show the dispersion or occurrence of particular values. This is the most common method of representing the distribution of features like population, agricultural products and livestock. Each dot represents a certain quantity or number (Fig. 42).

The choice of scale depends upon the total quantity to be represented on a given area in a map. Accordingly the quantity repre-

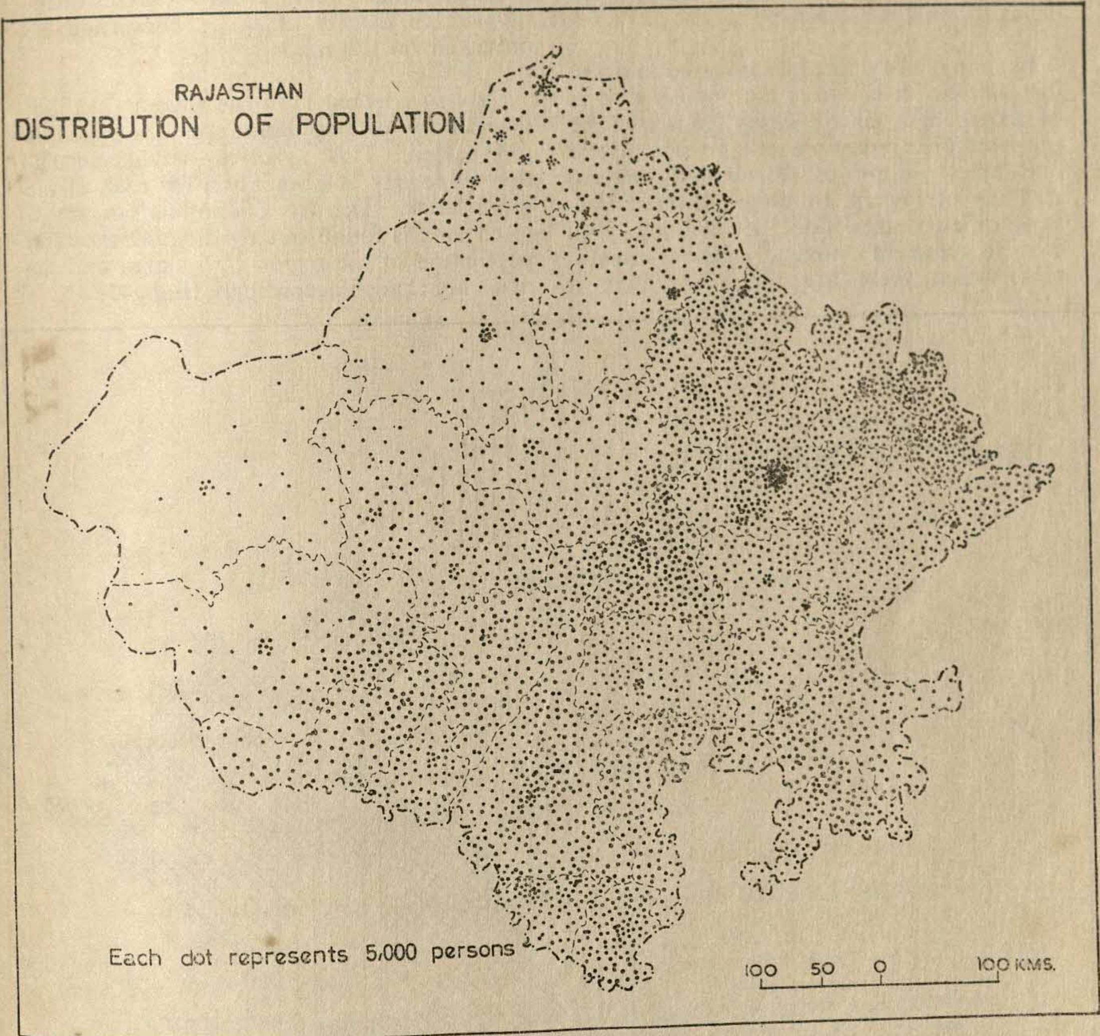

Fig. 42. A Map showing Distribution of Population by Dot Method

This map shows the distribution of population in Rajasthan for the year, 1961. This method clearly brings out the areas of concentration and sparsity. What precautions must be taken while preparing such maps?

sented by each dot is selected and the size of the dot is fixed. The scale is so chosen that there is no undue overcrowding of dots and the areas of minor production are not totally unrepresented. While placing the dots no parts of the region should be omitted unless they are negative areas. For example, cultivation of land is not possible in high mountainous regions or in extremely arid areas.

Dots should be of uniform size and the correct number of dots should be placed according to the chosen scale. To achieve uniformity in the size of the dots special pens are available and they should be used. In placing the dots the regions of concentration and sparsity are clearly brought out by this method. For example, in a crop distribution map, concentration of dots will

be in lowlands, plains, river valleys and deltas.

In spite of the difficulties involved in drawing dot maps it is one of the popular devices of geographers, since it easily lends itself for purposes of comparison. It presents a clear and exact picture of distribution patterns that are of interest to geographers. Sometimes different sizes of dots are used in a given map to represent different values or quantities. When there are too many dots it becomes difficult to find out the exact quantity or the density of the phenomenon represented on the map.

Shading Method : In the shading method, the density of population per unit area is represented. This involves actual calculation of density of population for each of the given units. Density of population for a given area is found out by dividing the total population of the region by its area and the areas are shaded accordingly (Fig. 43).

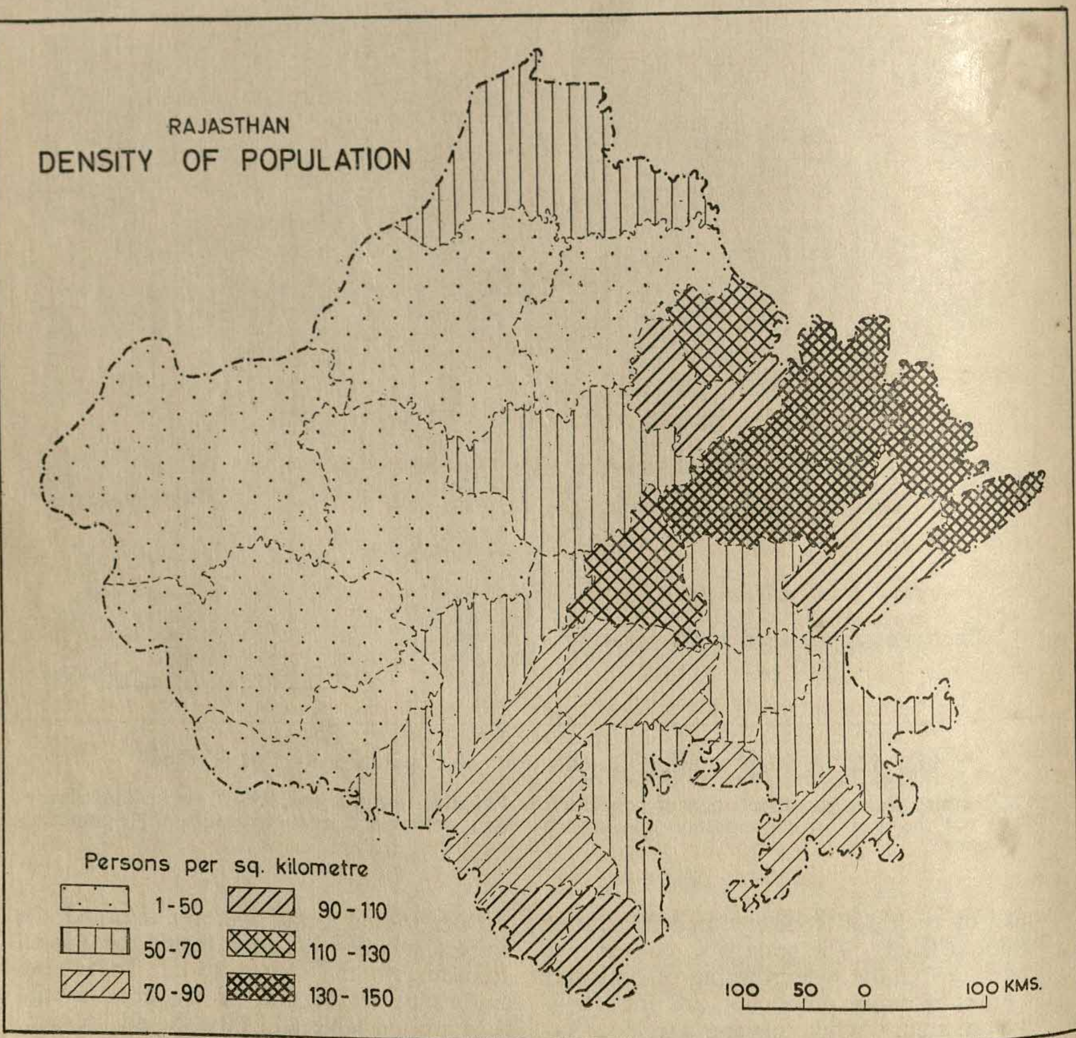

Fig. 43. A Map showing Distribution of Population by Shading Method

This map represents the same data as depicted in figure 42 but by the shading method. In what respect does this method differ from the dot method?

This method is similar to the layer tint method. Careful shading or tinting generally improves both the clarity and appearance of a map. As a rule, different colours are not used for quantitative shading, but the shades of a single colour are applied. It must be remembered that a change of colour. tends to give the impression of a change of phenomenon. Colours have to be artistically applied if they are to be pleasing.

The principle involved in these diagrams is to increase the depth of shading gradually from the smallest value to the largest. The category with the largest value is often conveniently shown in full black and the lowest by very light shading, or by widely spaced dots or by no shading at all.

EXERCISES

Review Questions

1. Answer the following questions:
   - (*i*) What are the different types of data presented on a map?
   - (*ii*) Name the types of maps according to their data.
   - (*iii*) What is a contour map? Define a contour.
   - (*iv*) Why are the data on temperature and rainfall shown by a line and bar graph?
2. Write short notes on:
   - (*i*) Vertical interval; (*ii*) A wind rose; (*iii*) A pictorial diagram; (*iv*) Interpolation of contours; (*v*) Line and bar graph; (*vi*) Profile; (*vii*) Form-lines.
3. What are the different methods of showing relief on a map? Discuss the merits and demerits of each method.
4. Explain what a distribution map is. Compare distribution maps drawn by the dot method and the shading method.
5. Give a single technical term for each of the following statements:
   - (*i*) Short straight lines drawn along the direction of maximum slope in order to give an idea of relief.
   - (*ii*) The height of a place found out in the field with the help of surveying instruments and plotted on the corresponding point on the map.
   - (*iii*) The accurate height of a specific point on a prominent and durable material object in the field recorded for the sake of permanent reference.

(*iv*) A slope of a hill whose contours are closer at the foot as compared to those at the top.

(*v*) A slope of a hill whose contours are closer at the top as compared to those at the foot.

(*vi*) Imaginary lines connecting places of equal temperature reduced to sea level.

(*vii*) Imaginary lines connecting places of equal rainfall.

6. Given below in the first column is the description of certain contour formations. The names of the relief features represented by them are listed in the second. Make out the correct pairs from the two:

(*i*) 'V-shaped contours where arms of 'V' point to the higher ground and the apex to the lower	(*i*) A waterfall
(*ii*) Contours merging into one while crossing a river or a stream	(*ii*) A conical hill
(*iii*) Contours running very close to one another ultimately merging into one	(*iii*) A valley
(*iv*) V-shaped contours where the arms of 'V' point to the lower ground and the apex to the higher	(*iv*) A cliff
(*v*) Contours forming more or less concentric circles at regular intervals	(*v*) A spur

7. Suggested below is a table comprising three columns. The first column refers to geographical data, the second pertains to the appropriate technique of graphical representation to be used in each case, and the third outlines the purposes to be achieved. The first item may serve you as a guide to fill up the blanks in the rest of the table. Complete the following table by filling the blanks appropriately :

S. No.	*Geographical Data*	*Graphical Technique*	*Purposes to be achieved*
(*i*)	Spot heights	Contours	(*i*) Depicting relief on a map with great accuracy.
(*ii*)	Area and population of each district in the Punjab.	....	(*ii*) Density of population of the whole state with districts as units.
(*iii*)	(*a*) (*b*)	A wind rose (modified)	Finding out (*i*) which winds are predominant at a given place for a certain period; and (*ii*) which of the winds are rain-bearing.
(*iv*)	The total value of Indian exports and their break up according to major commodities.	A wheel dia-diagram	(*i*) (*ii*)
(*v*)	Value of contours that cut a given straight line on a map.	A profile	(*i*)
(*vi*)	Monthly rainfall figures for a few stations in India.		(*i*) Comparing the rainfall regime of the given places.

Finding Out

Study carefully Figs. 42 and 43 showing the distribution of population in Rajasthan and try to find out answers to the following questions after correlating this map with the features of relief, drainage and climatic conditions in Rajasthan.

(*i*) Which part of Rajasthan is densely populated?

(*ii*) Name the district where the density of population is least.

(*iii*) How will you divide the state into two parts on the basis of theirpo pulation?

(*iv*) Which in your opinion is the physical feature that divides the state into two physical units?

(*v*) Compare these two units and try to explain the probable reasons for the marked contrast in the two.

Constructional Work

1. Prepare a line and bar graph to show the monthly rainfall and mean temperature of your town for a year.

   Prepare carefully a note explaining your graph and the conclusions that you draw from it.

2. Write a brief account of an imaginary island with varied and fascinating relief. Now transfer your word picture into a contour map using the accepted symbolic language of the map makers. See that your map is complete in all respects. Perhaps you may like to draw a cross-section along some line.

Films Available

Maps We Live By. No. 912; 17 mins; English; D.A.V.E.

Further Readings

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CHAPTER 5

Study of Maps

THE MAP is the most important tool of a geographer. It is useful, however, not only to a geographer but also to almost all citizens—to travellers, tourists, administrators, planners, architects, engineers, civil and defence personnel, scholars and laymen. Different maps are used by different people according to their requirements. They are indispensable to us because they contain a wealth of information accurately depicted in a relatively small space and they can be readily interpreted with some practice. This explains why today more and more people are becoming increasingly map-conscious.

Maps are classified in two different ways. One of the classifications of maps is based on their scale, while the other relates to their function.

According to scale, maps are classified into three types—cadastral, topographic and atlas maps.

Cadastral Maps: Strictly, these are the maps that pertain to cadastre, i.e., a public register of the lands of a country for the purpose of defining property in legal documents and levying taxes. In practice, however, it includes maps drawn on a fairly large scale to show accurately the extent and measurement of every field and plot of land. For example, maps drawn on the scale of 1 : 2,500 or 25 inch-map, i.e., where 25 inches on the map represent one mile on the ground, are cadastral maps.

Topographic Maps: These maps are intermediate between a general map or a small scale map on the one hand and a plan or a cadastral map on the other. They are based on the actual survey of the land and their scale is large enough to show roads, plans of towns, contour-lines and other details. But they do not show boundaries of individual fields and plots. They usually depict the detailed surface features as forests, rivers, lakes and man-made or cultural features such as roads, railways, canals and settlements.

Common scales of topographic maps or topo-sheets, as they are generally called, are 1 : 50,000; 1 : 62,500; 1 : 63,360 or 1 : 100,000.

Atlas and Wall Maps : If cadastral or large scale maps stand at one end of the scale, the atlas and wall maps stand at the other. The *atlas maps* are small scale maps. They represent a fairly large area at a glance and present a bird's-eye view of a region and as such do not depict all the details which a topo-sheet does.

Even so, an atlas map serves as a graphic encyclopaedia of geographical information about different parts of the world to those who know its language or understand how to consult it. When consulted properly, it lends a wealth of generalized information regarding location, relief, vegetation, climate and distribution of population. Their systematic use gives an insight into the major economic activities and political events discussed in daily newspapers.

Wall Maps: These are essentially atlas maps that are enlarged for display purposes. In that sense they are large-scale maps as

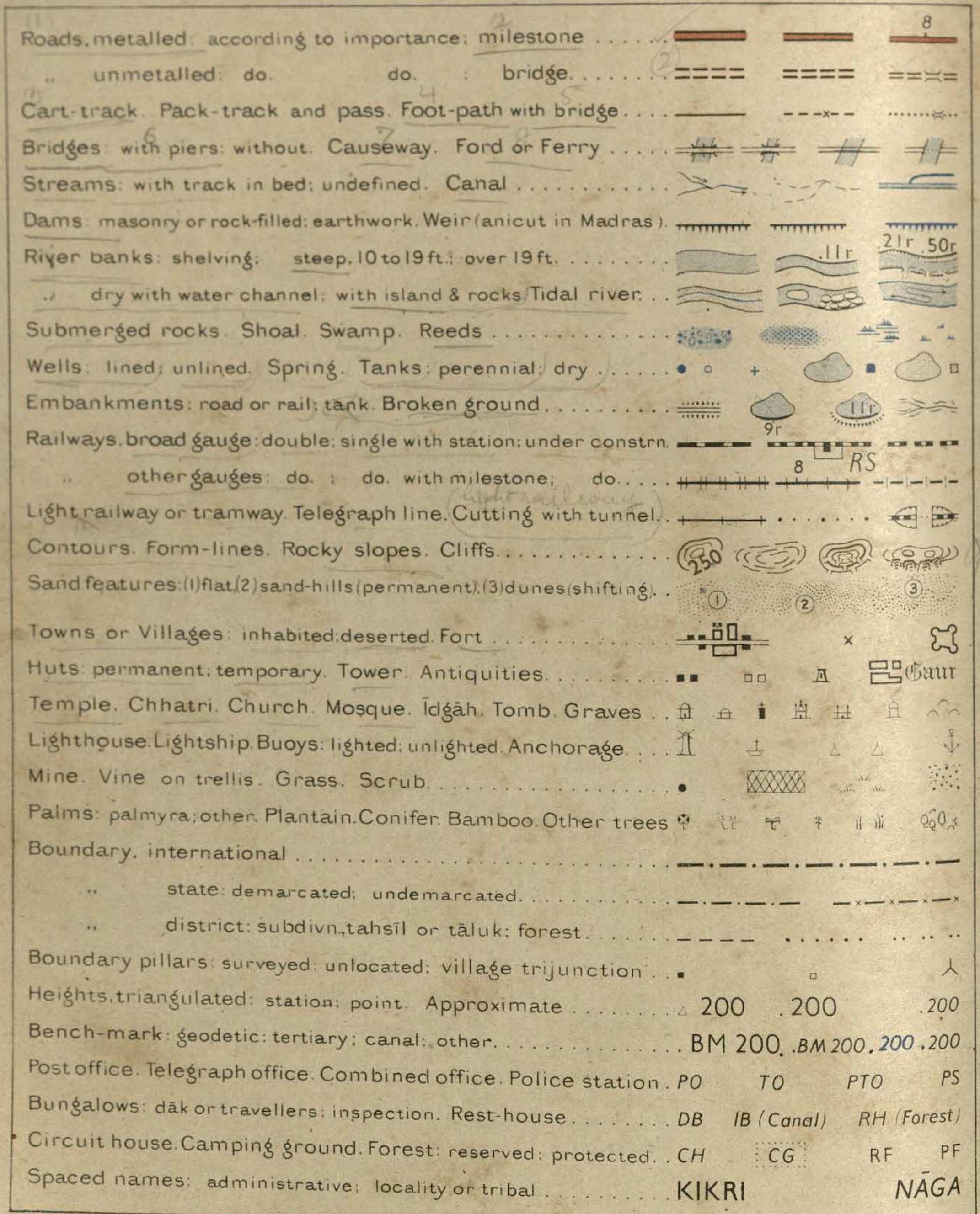

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Fig. 44. Conventional Signs used in the Survey of India Topo-sheets.

The conventional signs form the alphabet of the language of maps.
Study carefully the various conventional signs.

compared to an atlas map. Nevertheless, they usually do not show any more details than what the small scale atlas maps do. These maps are particularly useful for large groups and classes as they can be hung on the wall and can be read at a distance by all.

The second classification of maps relates to their functions. For example, atlas maps consist of a large variety. Maps may show relief, climate, vegetation, population, means of transport, land use patterns, and political divisions. The important among these are relief, climate and population maps.

Relief Maps: Relief maps give us an idea of surface features or landforms such as plains, valleys, plateaus, ridges and mountains. They also provide information regarding the drainage of the region. With a little practice, it becomes possible to visualize the landscape and its elevation.

These maps are useful for getting an idea of relief. They are helpful in finding out suitable sites for human settlements, construction of roads, dams and canals. To a certain degree they provide a clue to the agricultural potential of the region depending upon how plain or hilly is the terrain and its water resources.

Climatic Maps: Climatic maps provide us with information regarding temperature, pressure, rainfall, winds and sky conditions. They supply generalized information based on data collected over a period of time. These maps give us an idea of climatic conditions in different parts of the world.

Information provided by these maps is useful in determining natural vegetation and agricultural produce. It also throws light on how favourable or otherwise is the region for human habitation.

Population Maps: These maps are drawn to show the distribution of population in different regions. Some maps give us an idea of the density of population in various regions, whereas others, through the dot method, indicate both the absolute population and its density. These maps are helpful in planning a balanced development of various regions through the development of suitable industries, construction of means of transport and communication lines and the establishment of new centres of trade and commerce.

For students of geography, population maps offer an opportunity to correlate the distribution of population with various geographical factors, viz., nature of relief, agricultural resources, climatic conditions, ground water, mineral resources, and industrial development of the region.

Reading of topographic maps or topo-sheets involves the "*setting*" of the maps and understanding their conventional language comprising signs, symbols and scales used in depicting the various physical and cultural features.

Setting of the Map: When one reads a local topo-sheet, it is necessary that it must be set properly, i.e., the north point on the map should correspond with the True North. We usually use a magnetic compass to find out the North. But it must be remembered that the North shown by the magnetic compass is not the True North or the Geographic North but the Magnetic North. Once we find out the Magnetic North we can easily locate the True North fairly accurately, since the magnetic declination or the degree of variation of the True North from the Magnetic North is indicated on every topo-sheet.

Use of Conventional Signs

Setting of the map and understanding its scale are the important preliminaries of map-reading. Equally important is the fact that the map-reader should make himself familiar with the symbols used on the map for which at least a skeleton-legend is provided on the topo-sheet, in the form of a key. The purpose of using such symbols on a map is to make it both informative and legible as far as possible. The common symbols, including the letters used for representing various relief and cultural features, are known as *conventional signs* (Fig. 44).

A reader who is familiar with the conventional signs used by the Survey of India on its topo-sheets, can read almost any map

of any country, even if the language is foreign, like French or German, without much difficulty, since most of these symbols are of universal applicability.

Study of Topographic Sheets

The heads under which a topographic sheet is usually interpreted are : (*i*) marginal information, (*ii*) relief and drainage, (*iii*) land use, (*iv*) means of transport and communication, and (*v*) human settlements.

Under 'marginal information,' answers to the following questions are generally sought : What is the name and number of the sheet ? Which specific area does the sheet depict? What is its latitudinal and longitudinal extent ? Who are the publishers of the sheet ? When has it been published and on what scale ? What is the approximate total area of the region covered by the map ? Are there any special facts of physical and human geography ?

The common questions raised under the head 'relief and drainage' are : What is the contour interval used in the given sheet ? What are the prominent physical units into which the region can be conveniently divided ? How can these different geographical units be described ? What are the major landforms, such as plains, plateaus, valleys, and hills, represented on the sheet ? Are there any characteristic features of these landforms ? Is there any prominent water divide in the region? Are there any peculiarities in the drainage system ? Can anything be said about the general slope of the region and the gradient of the prominent river ?

The next aspect of the study deals with land use and, therefore, an attempt has to be made to elicit information regarding types of vegetation, and possible clues regarding climatic conditions and probable occupations of the people in the region. The questions pertinent in this regard are such as these : What is the natural vegetation found in the region ? What are the important ways in which the land is used ? What are the possible major occupations, or sources of livelihood of the people?

The information on means of transport and communication is sought from the given sheet through such questions as : What are the different means of transport in the region ? Is the area served by railways and roads ? How adequate are they ? Are there telegraph and telephone lines besides post-offices? What do the various lines of transport and communication indicate regarding the industrial development and general prosperity of the people? Is there any correlation between the topographical features and the main lines of communication? Is there any relationship between the means of transport and the patterns of settlement ?

The next query pertains to human settlements. The information on this point also throws light on land use and occupations of the people. The questions that are useful in this regard are : Which are the urban centres in the region ? How big are they ? In what activities do they specialize ? Are they industrial or commercial towns or administrative centres? How favourable are the locational factors for their growth? How dense are the rural settlements?

A few plates from the Survey of India one-inch topographic maps are included in this chapter for careful study. These are only the small portions of a big sheet. Two or three plates from each sheet are reproduced with a view to giving an idea of as large a portion of the sheet as possible by fitting them together.

The sheets that have been selected represent different regions of India, for example, a part of Thana District in the coastal strip of Konkan; a portion of Chingleput District, Madras, on the eastern coast; the edge of the Vindhyan Plateau and the part of the Gangetic Plain around Mirzapur, Uttar Pradesh; a portion of Aravalli Hills, south of Ajmer, in Rajasthan; and a part of Siwalik Hills between Chandigarh and Kalka.

THE LOWLYING VALLEY OF THE ULHAS RIVER

This is a portion of a one-inch topo-sheet No. 47E/4 published by the Survey of India. It represents a part of Thana District in Maharashtra. The tidal estuary of the

Plate I

THE LOWLYING VALLEY OF THE ULHĀS RIVER

Part of Sheet No. 47 E/4

Reg. No. 8 8 0 2 HE'66-5000.
0′ E. of GREENWICH.

Scale 1″=1 Mile.

CONTOUR INTERVAL 50 FEET.

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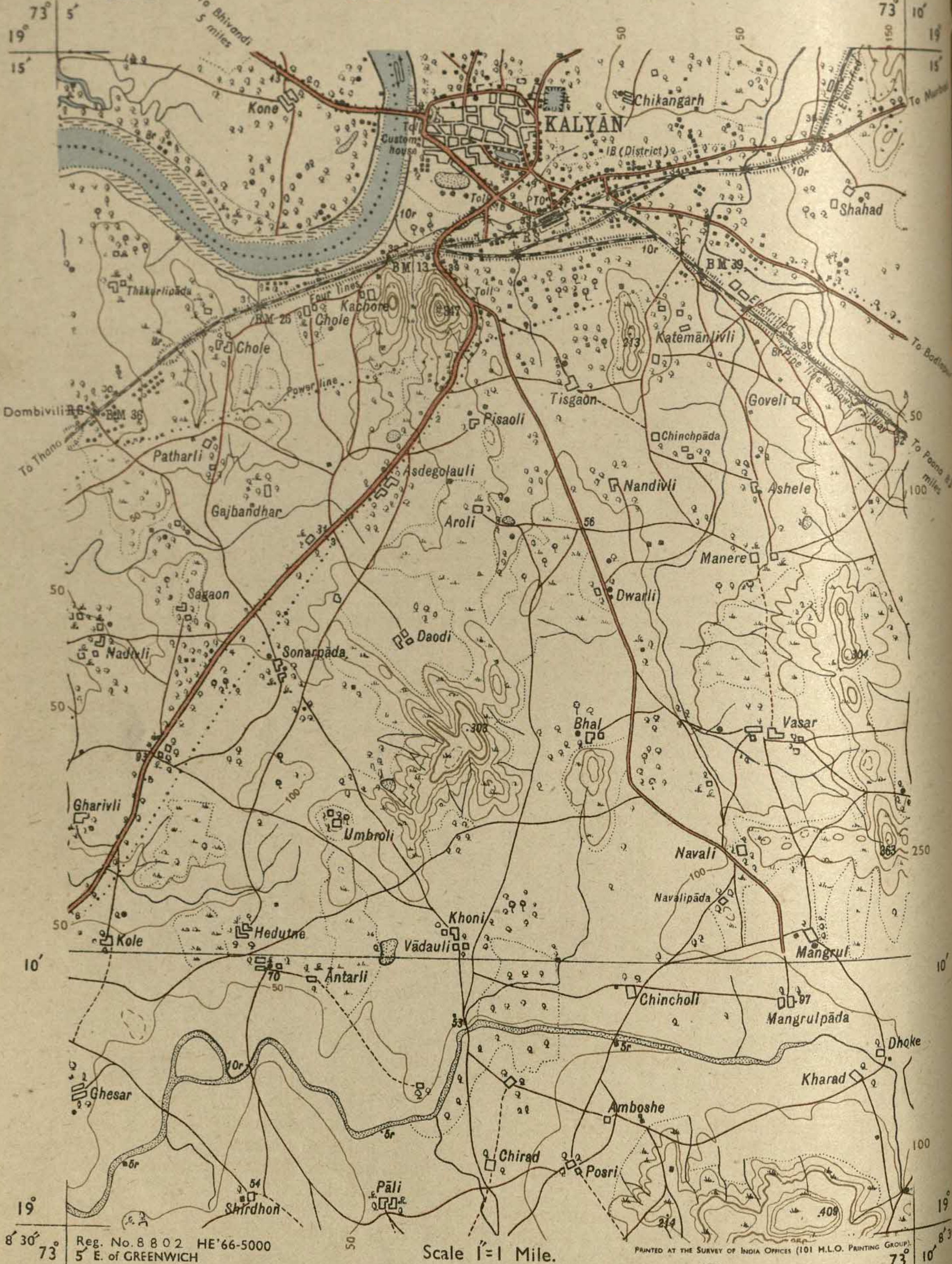
Reproduced from Survey of India Sheet No. 47 E/4 on scale 1″=1 mile with the permission of the Surveyor General of India, 1966.

Plate 2 KALYĀN: A NODAL TOWN Part of Sheet No. 47 E/4



Scale 1"=1 Mile.

CONTOUR INTERVAL 50 FEET.

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Ulhas river is the important physical feature of this area. The river falls into Bombay harbour in the west only a few kilometres further downstream. A few lifelines that sustain the metropolitan city of Bombay pass through this area.

The area shown on the map ranges between 19°10′N. and 19°15′N. and between 73°E. and 73°5′E. with a total area of about 100 square kilometres or 40 square miles.

The region can be divided into two physical units : (*i*) a lowlying Ulhas Valley, and (*ii*) a north-south ridge in the south-west rising sharply over the surrounding lowland.

Most of the region except the ridge in the south-western part is less than 50 feet (about 16 metres) above sea level. However, the region is not a dead level land, rather, it is undulating with small hills and spurs on either side of the river.

The meandering course of a river suggests that the river is in its lower course flowing in a fairly flat region. Throughout its course, the river banks are marked with a low water line and a high water line. This indicates the tidal nature of the river.

·Note the symbol used for showing tidal limit. The marshes along the river are due to tidal waters. Many of the small streams joining the river are only seasonal streams beyond the tidal limit. This further indicates that the perennial nature of several streams is primarily determined by the tidal limit.

The hills in the south-western part is a good example of a ridge. Describe the trend of the crest line, note the peaks and their heights, measure the length and the width of the ridge and draw a cross-section along the tunnel passing through the Dhup Dongar. In the local language of this area, the word *dongar* means a large hill.

What vegetation do you notice in this region? Where would you look for tidal flora?

Which are the main lines of communication? How adequate are they to serve the local needs? Can you draw any inference regarding the nature of the traffic?

In what way does the relief of the region influence the course of the major lines of communication? Study carefully the impact of the river Ulhas and the ridge on the railway lines and the national highway.

Besides the lines of communication, which are the other life lines of the metropolitan city of Bombay that pass through this area ?

How dense are the rural settlements ? Which is the most important natural resource in the south-western part of the area ?

Are there any urban centres in this area ? How would you account for this particular situation ?

KALYAN : A NODAL TOWN

The nodal position of Kalyan town is the important feature of the area shown on this sheet. In the past, it was an important administrative centre commanding the approaches to the Bor Ghat and the Thal Ghat, one to its north-east and the other to the south-east in the Western Ghats. In the local language the word *ghat* means a pass. Today, the town stands at the junction of the railway lines that pass through these *ghats* and connect Bombay city with the rest of India.

Study the latitudinal and longitudinal extent of the area shown on the map and find out its position in relation to the region shown in the previous sheet.

How would you describe the general relief of the area? Would you call it an undulating plain with isolated hills ?

On what river is the town situated ? Is it a tidal river ? Note that the banks of the river near the town are steep with a height of 10 to 19 feet. Is there any other stream in this area? Is it a perennial stream? There are a few tanks in the town. Some of them are shown in blue while one is not. What does it indicate?

What type of trees do you find in this area ?

Do you notice any change in vegetation on this and on the previous sheet ?

If you study both the plates you would notice that there are only two road-bridges across the river Ulhas. One is in the vicinity of Thana in the west and the other near Kalyan. What natural factors are in favour of constructing bridges at these places ? Do you think that the town of Kalyan can depend upon the river for its water supply ?

As many as seven metalled roads and three railway lines of national importance meet at Kalyan. Trace the various railway routes and roads converging on this town. Study carefully the relationship between these lines of communication and the local physical features such as the river and hills lying to the south and south- west of Kalyan. Locate the various power lines, pipelines, telephone lines, etc., on the map.

Note carefully the railway cuttings and embankments. What symbols are used to show a cutting, an embankment and a tunnel? What idea do you get from them regarding the nature of the terrain ?

The rural settlements are sparse but fairly big and compact. They are connected with the main roads by cart tracks. What symbols are used to indicate metalled roads, unmetalled roads and cart tracks ?

ARANI : A COASTAL LOWLAND

This is another sheet depicting a coastal lowland. It is a portion of topographic sheet No. 66 C/3. The area shown on the map is in Chingleput District, Madras. The city of Madras is only 16 miles south of this area. Tank irrigation is an important feature of this predominantly agricultural region.

Locate this area on a map of India in your atlas with the help of the latitudes and longitudes given on this sheet.

How would you describe the nature of the terrain? How does it differ from that of the previous sheet? This is an example of a gently rolling lowland with a couple of isolated knolls. Note the height of a knoll south of Manjankaranai. The region as a whole has a gentle slope towards the east. How do you infer this ?

Name the two rivers flowing through this area. Are they perennial streams? What inference can you draw from this fact regarding the local regime of rainfall? The rivers have mostly steep banks. What type of terrain does it suggest?

Which is the largest tank in this region ? Is it a perennial tank? Is it a natural or a man-made feature? There are quite a few tanks scattered all over the region. Some are small, some are big. Most of them are natural tanks with a perennial water supply. What makes you think that tank irrigation is very important in this area? Are there also wells in this region? What symbols are used to indicate lined and unlined wells? Which type of wells are predominant?

Note the banana plantations in this area. What are the other trees? What types of natural vegetation are found in this region?

See the road running north-south almost in a straight line across the region. It generally indicates that the region is flat and devoid of major physical obstructions. Find out how level the road is with the help of bench marks plotted along the roadside.

Study the settlements. Are there any urban settlements in this area? Which is the largest settlement shown on this sheet? What factors favour its location?

Do you find any relationship between tanks and the location of settlements in this area? What does it suggest?

PONNERI : A COASTAL LOWLAND

This sheet is in continuation of the previous one, and it represents the adjoining area in the east. The area shown on this map is similar to the previous one in most respects. However, a careful study of this sheet and its comparison with the previous plate would reveal a few differences.

Find out the location of the area represented on this map in relation to that of the previous sheet.

Plate 3

ARANI : A COASTAL LOWLAND

Part of Sheet No. 66 C/3

Reg. No. 8802 HE'66-2500.
80° 5' E. of GREENWICH.

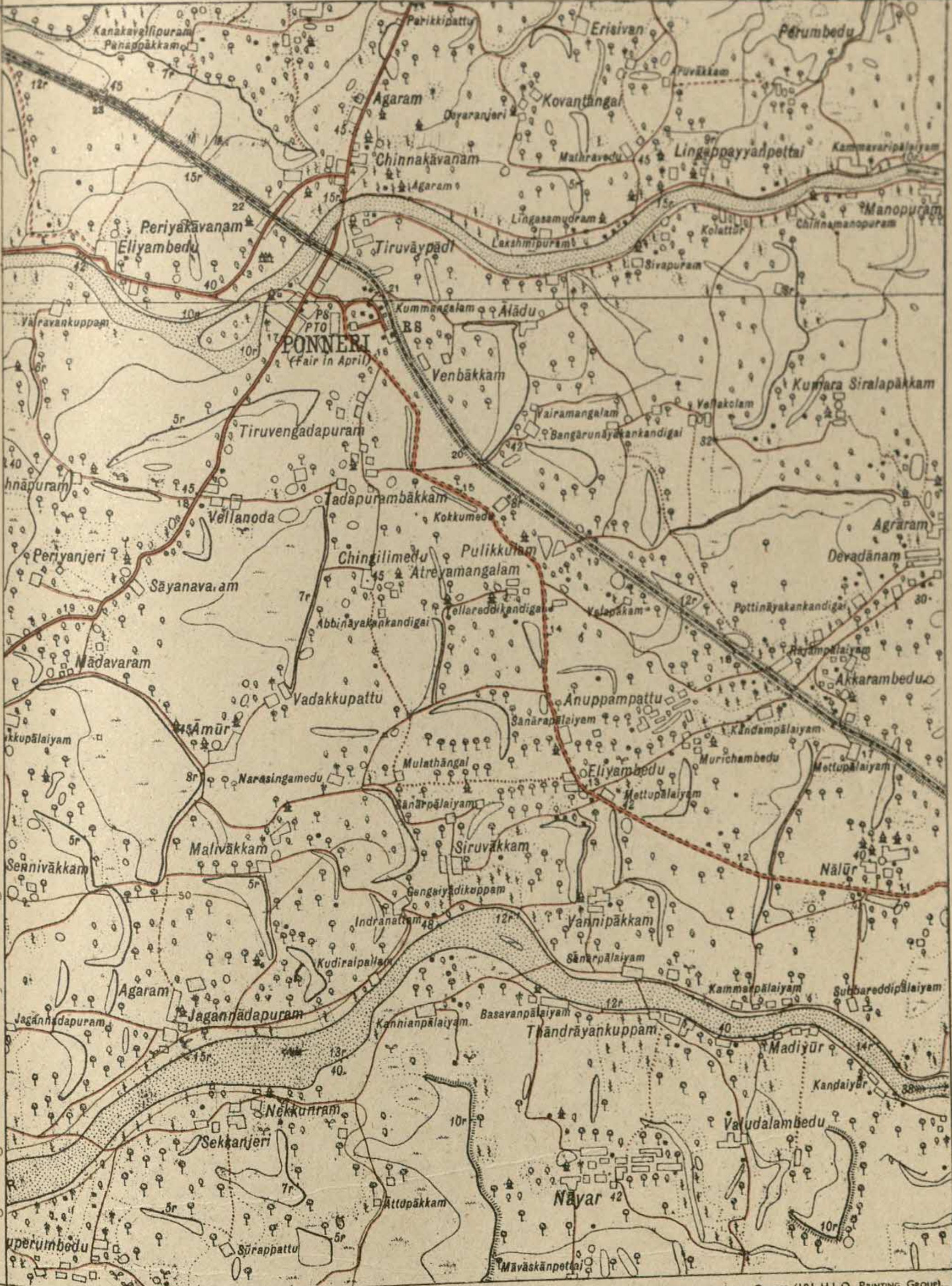
Scale 1" = 1 Mile.

CONTOUR INTERVAL 50 FEET

Plate 4

PONNERI : A COASTAL LOWLAND

Part of Sheet No. 66 C/3



Reg. No. 8802 HE '66-2500.

80° 10' E. of GREENWICH.

Scale 1" = 1 Mile.

CONTOUR INTERVAL 50 FEET.

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1966.

Reg. No. 1279 PZE'66-2500.

Scale 1" = 1 Mile.

CONTOUR INTERVAL 50 FEET.

82° 30' E. of GREENWICH.

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The sheet represents a flat lowland with a very gentle slope towards the east. Most of the region is below 50 feet above sea level. Find out the lowest elevation marked on the map. Where would you look for the lowest point on your sheet?

Compare the river courses as shown on the two sheets. The river-beds are dry for a part of the year although they possess fairly wide channels. The presence of islands in the river channel indicates a very low gradient of the river. The river banks are steep with their heights ranging from 10 to 15 feet.

The region is studded with perennial tanks. Many of the tanks are small in size as compared to those in the previous sheet.

Vegetation in this region is varied. It consists of grasses, palmyras, other palms and deciduous trees. The coconut palms, banana plants and casurina trees seem to be of economic significance. Compare the vegetation in this region with that of the previous sheet. Is it more thick or sparse? What does it suggest?

Compare the railway lines shown on this sheet with those on the first two plates. How does this railway line differ from those? Study carefully the symbols used to indicate broad gauge double line, broad gauge single line, metre gauge double line and metre gauge single line rail tracks.

Note carefully that there are embankments all along the railway line. What does it indicate as regards the nature of the terrain?

Compare the nature of traffic in this area with that of the first plate. What marked difference do you note in the two?

Study the settlements shown on this sheet and compare them with those on the previous sheet. What inference can you draw regarding the density of population and the main occupation of the people? What do you think are the main agricultural products in this area?

THE VINDHYAN PLATEAU IN MIRZAPUR DISTRICT

The plate shows only a portion of a sheet No. 63 K/12. It represents part of Mirzapur District, Uttar Pradesh. The important physical feature of the area is a plateau region that is a continuation of the Kaimur Hills of the Vindhyas, lying a few kilometres south of this region.

How would you locate this area on a map of India ? Would the latitudes and longitudes mentioned on the sheet help you in this regard?

Note the maximum and minimum heights mentioned on this sheet. A bold contour line of 500 feet running across the region in the north and in the east is of significance in studying the relief of this area. Note the other three or four contours that are very close and almost parallel to it. What do they indicate? They represent a steep slope. What is the amount of fall or rise near Rajghat in the north-eastern part of the sheet? The sudden fall in the level of an elevated and fairly flat land as marked by the closely set contours running almost parallel to one another, represents the steep edge of a plateau.

Study the land enclosed partially or wholly by the contour-line of 500 feet. What type of relief does it represent? Are there any residual hills on the plateau region? Describe them if any.

Note carefully the zigzag shape of the contours that mark the edge of the plateau. What is it due to? Is there any relationship between the rivers and the shape of the plateau? A plateau that is interspersed with deep and numerous river valleys is called a dissected plateau. Would you describe this area as a dissected plateau? Substantiate your answer with specific examples.

Draw a section along the line joining Majhwani village in the south-east and the temple in Chitpur village in the north. Describe the major landmarks and landforms along this line with the help of the profile drawn by you.

There are two rivers in this region, one flowing in the west and the other in the east. In what direction do they flow? In what respect do they differ from each other?

Note a big waterfall on the river that flows in the western part of the plateau. Name the fall and find out its height. Which is the largest tank in the region? Is it a natural or an artificial tank? Find out the length and the maximum height of its embankment.

What vegetation do you find in this region? Which is the favoured location for the vegetation in this area?

There are three roads in this area. Study carefully the alignment of the road in the northern portion of the sheet. What is the impact of the relief of this area on the alignment of the road? Find out the length of this road in miles as well as in kilometres.

Note that there are no settlements in the two river valleys referred to above. However, there are settlements along the river and its tributaries flowing into the tank—Tandadari Tal. How would you account for this situation? What is the main occupation of the people in this area?

MIRZAPUR : A RIVER TOWN

This plate is in continuation of the previous one as it represents an adjoining area in the north. The map represents typical features of the Ganga Plain in eastern Uttar Pradesh. The location of Mirzapur, an important river town in the region, adds to the significance of this sheet.

Locate the area represented on this sheet on a small-scale map of India with the help of latitudes and longitudes mentioned on this plate. State the location of this region in relation to the area shown on the previous sheet.

How would you describe the relief of this area? Note the value of the contour-line running along the southern margin of the sheet. Except for a few contour-lines in the south-eastern part of the region they are almost conspicuous by their absence. What does it suggest? Find out the minimum, maximum and average elevation of the entire region. How would you do it in the absence of contour-lines? In what direction is the general slope of the area? How does the relief of this region differ from that of the area shown on the previous sheet?

Observe the course of the two rivers running along the eastern and western margins of the sheet. What does it indicate as regards the relief of the region through which they flow? What technical term is used to describe the nature of such a course?

Note the ravines in the western part of the sheet. What do they suggest?

Study carefully the channel of the Ganga river along the northern margin of the sheet. Compare the two banks of this river. What difference do you notice? Which terms would you use to describe these two types of banks? Remember that the river shown on the map is only a part of a big loop. The northern bank of the river is, in fact, the inner bank of the loop. Note the sand deposits on this bank. How steep is the southern bank ? This is the outer bank of the loop.

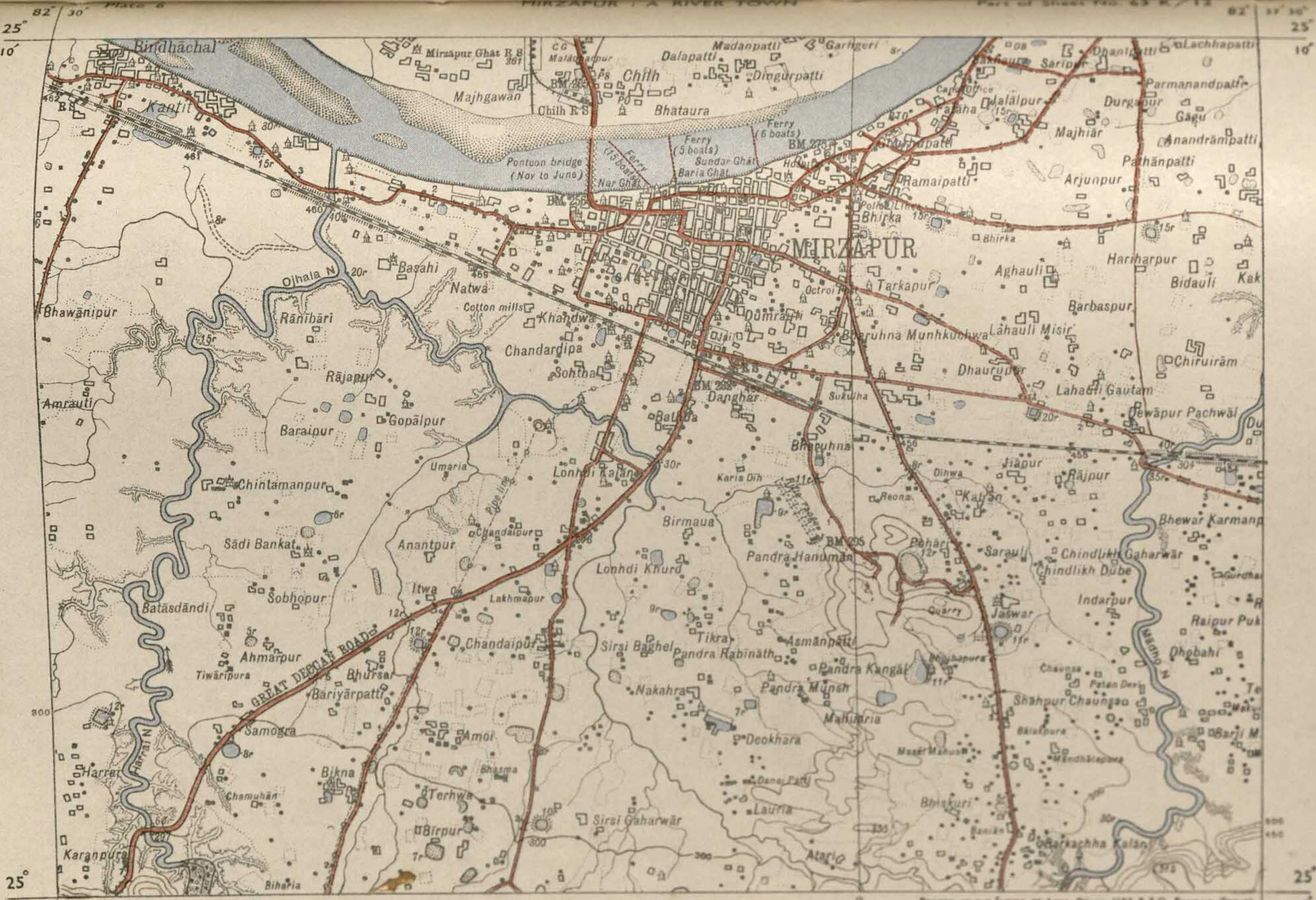
Note the presence of deciduous trees in this area which give it the appearance of an open woodland.

Which are the major lines of communication that serve this area? Note the alignment of the main railway line. What does its straight course indicate? See how different metalled roads converge on Mirzapur town. To what extent is the river used for transport? Where do you think is the maximum river traffic? In what seasons is the pontoon bridge used for crossing the river?

Note the size of the village settlements. Many of them are open but compact settlements of fairly large size. There are also a few permanent scattered huts. Are there temporary huts as well? Do you find any relationship between the perennial tanks and the location of big villages? Is there any correlation between the roads and the settlements?

What do you think is the major occupation of the people? What are the sources of irrigation in this region?

What factors in your opinion favour the



Reg. No. 1279 PZE'66-2500.
30′ E. of GREENWICH.

Scale 1″=1 Mile.

CONTOUR INTERVAL 50 FEET.

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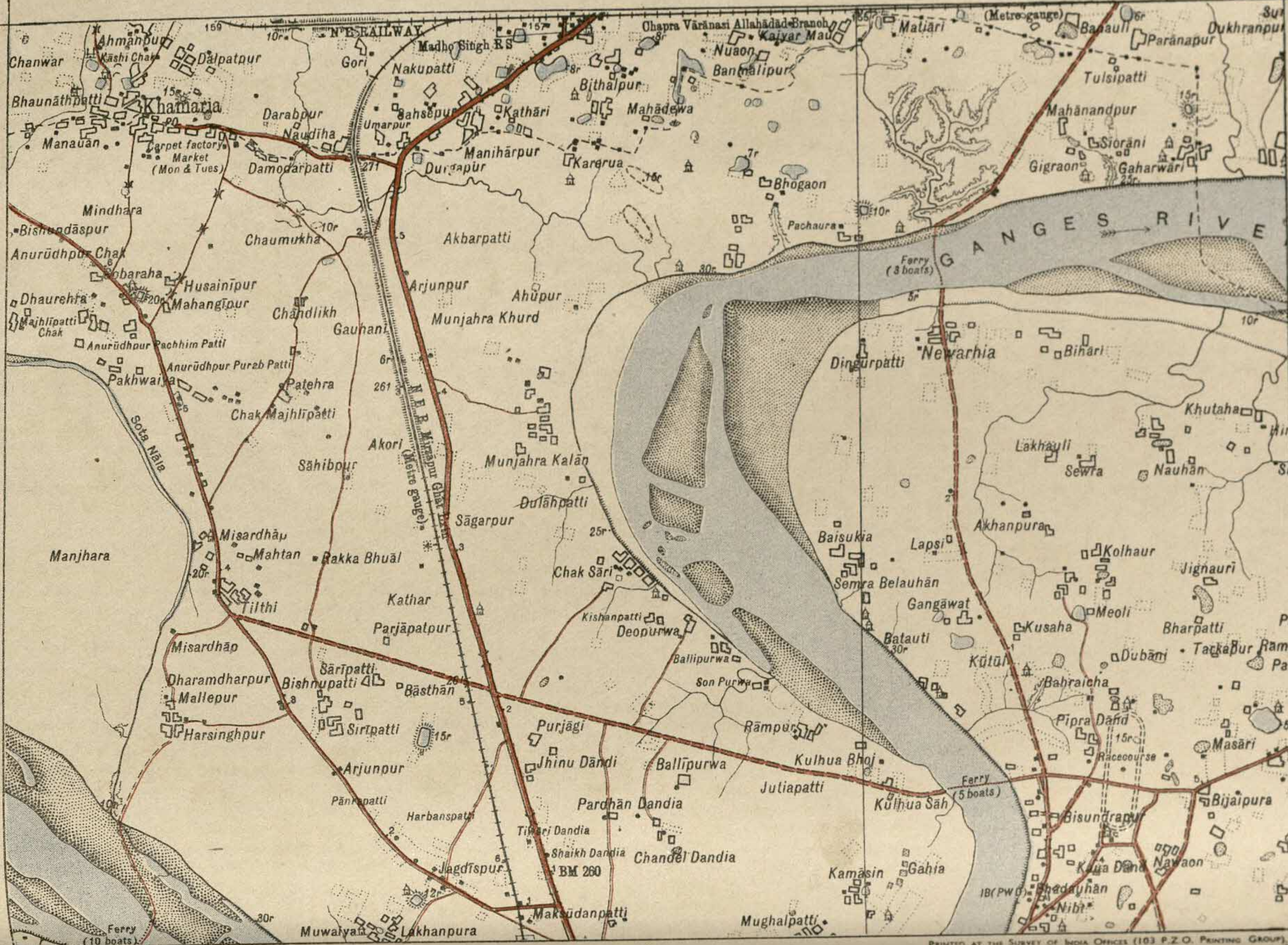
1966.

Plate 7

A FLOOD PLAIN OF THE GANGA

Part of Sheet No. 63 K/12



Reg. No. 1279 PZE'66-2500.
30′ E. of GREENWICH.

Scale 1″=1 Mile.
CONTOUR INTERVAL 50 FEET.

Reg. No. 8802 HE'66-2500.
22° 30′ E. of GREENWICH.

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CONTOUR INTERVAL 50 FEET.

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Plate 8-A : Aerial photograph of the area marked A B C D in plate 8. Note how the Aravali Hills look from above. Study carefully the alignment of the road and the location of settlements. (*Scale* : 2 inches—1 mile)

location and growth of Mirzapur town? Why do you think that this town could not be located on the northern banks of the River Ganga? Compare the location of Bindhachal with that of Mirzapur. Which of the two sites is more favourable and why? What makes you think that Bindhachal is a place of religious importance?

A FLOOD PLAIN OF THE GANGA

This plate is a portion of topo-sheet No. 63 K/12 and is in continuation of the previous two plates. The map represents the portion of Mirzapur District and the southern tip of Banaras District. The meandering course of the River Ganga through its flood plain is the major feature of geographical importance in this area.

Fix the location of the area with the help of latitudes and longitudes mentioned on the sheet. Consult the scale and find out the length of the river course and its maximum and minimum width. Fit the two plates together in order to measure the exact length of the river.

The complete absence of contours on this map points out the smooth topography of the region. The monotony of this homogeneous region is broken by the meandering course of the Ganga. But for a couple of isolated knolls and a small patch of ravine lands in the north–eastern part of the region, the entire area presents a smooth topography. The knolls are shown by form-lines. How do the form-lines differ from a contour? What special purpose do they serve?

What indicates that the river has a very low gradient? How would you account for the presence of sand deposits on the river-bed and along the banks? Note that there are no sand deposits where the river is confined to a narrow channel. On the other hand the large-scale sand deposits occur where the river spreads over a broad channel. See that the sand deposits are generally found along the inner bank of a loop where the velocity of water current is usually low as compared to what it is along the outer bank. The loss of the velocity of river-water decreases its capacity to carry load, leading to the deposition of sand on the river-bed.

River banks are steep along the outer bank of a loop as the river water moves very fast along this bank causing lateral erosion. The banks are shelving along the inner bank of a loop.

Note that the trees in this region are few. They are, however, found along the metalled roads. In the north there are some orchards or plantations, perhaps mango groves.

A railway line runs along the northern margin of the sheet. One of its branches runs north–south up to the River Ganga. The name Mirzapur Ghat Railway Station (see previous plate) suggests the importance of Mirzapur town on the opposite bank of the the river. It is a metre-gauge single line track. A metalled road also runs parallel to the railway line, and crosses the river by a pontoon bridge.

Compare the settlements on the two sides of the river on this and on the previous sheet. How would you explain the sparsity of settlements in the major part of this sheet? The settlements are again fairly dense in the northern part of the region. What does it indicate? How would you explain the presence of large-size compact villages along the northern bank of the river on the previous sheet when most of the area is without settlements?

ARAVALLI HILLS IN AJMER DISTRICT

This is a portion of topographic sheet No. 45 J/8. The map represents a part of Ajmer District in Rajasthan. The part of the Aravalli range passing through this area is the significant feature of this region. The Aravallis are one of the oldest mountains on the earth. Now they represent only the remnants of the once-lofty mountain chains.

Note the latitudinal and longitudinal extent of this sheet and calculate the total area represented on the map. Locate this region on a map in your atlas.

Based on its relief, the region may be divided into four separate units—the north-western hilly region, the broad valley region, the elongated hilly region, and the south-east plain. All these units run parallel to one

another. The broad valley region and the elongated hilly region are the important units.

Draw a cross-section along a line joining the north-western and south-eastern extremities of the sheet. Name the roads, rivers and the crest of the ridges along this profile.

The extensive water divide between the streams flowing north-west and south-east is narrow and long with scarp slopes on both sides. Can you calculate how high these escarpments rise above the base of the hills? The average elevation of the water divide is 1,850 feet above sea level. Trace its crest line.

The north-western hilly region is a ridge with a rather low elevation. Spot height 1,673 is the highest point of this ridge. What is the contour-interval used on the map?

What type of topography does the broad valley region and the south-east plain represent? Is it very flat, gently sloping in one direction or undulating? What is its general elevation?

The streams in this region are all seasonal except one which is fed by man-made perennial tanks.

Most of the plain area is under cultivation. From the seasonal nature of the streams, it can be inferred that there is inadequate rain fall in this region. It has to depend on irrigational facilities as is clear from tanks, embankments and wells all over the region.

With the exception of two wooded areas, trees are very sparse. What vegetation do you find in this region?

The region is mainly served by cart tracks. How many main routes cross this region? Correlate these lines of communication with the physical features of the area.

Note the size of the settlements. They are large and compact settlements. The settlements are, however, very sparse and clearly indicate the sparsity of population.

BEAWAR—LOCATION OF A NEW TOWNSHIP

This plate is in continuation of the previous sheet as it depicts the adjoining region in the west. Besides Ajmer District, the area shown on the map also includes a part of Pali District of Rajasthan. The city of Ajmer is only 18 miles north-east of this region. The nodal position of the township of Beawar (Nayanagar) is a significant feature of the area represented on the sheet.

Stretching between 26°5′N. and 26°10′ N. and between 74°15′ E. and 74°22′E, the region covers an area of about 40 square miles or 100 square kilometres.

Locate the highest and the lowest points on the map. What is the difference in their elevation? Examine carefully the contour-lines and spot heights given on the map. Shade lightly the land over 1,500 feet in height and thus locate the hilly areas on the map. Can you divide the area into different physical units? How would you describe them?

Except for a few small isolated hills and knolls, the broad valley region has a smooth topography. The few hills, however, rise more than 200 feet above the surrounding region and they are more or less rounded at the top. What is the general elevation of the valley region? Where are the ravine lands in this area?

The main streams of this region are the tributaries of the Makrera river. Are these streams seasonal or perennial? Note the valleys of the streams in the hilly area. Does the spacing of contours give any idea regarding the shape of these valleys and the steepness of the hills? To what extent is the hilly region dissected by streams?

Note the man-made features that aim at improving the drainage system of this area. How are the embankments shown on the map? Are they very common in this area? The drainage pattern in the south-western part of the area presents an interesting feature. The streams radiating in all directions represent a radial pattern of drainage. The radial drainage found in this area is, of

Plate 9

BEĀWAR : LOCATION OF A NEW TOWNSHIP

Part of Sheet No. 45 J/8

Reg. No 8 8 0 2 HE'66-2500.

74° 15' E. of GREENWICH.

Scale 1"=1 Mile.

CONTOUR INTERVAL 50 FEET.

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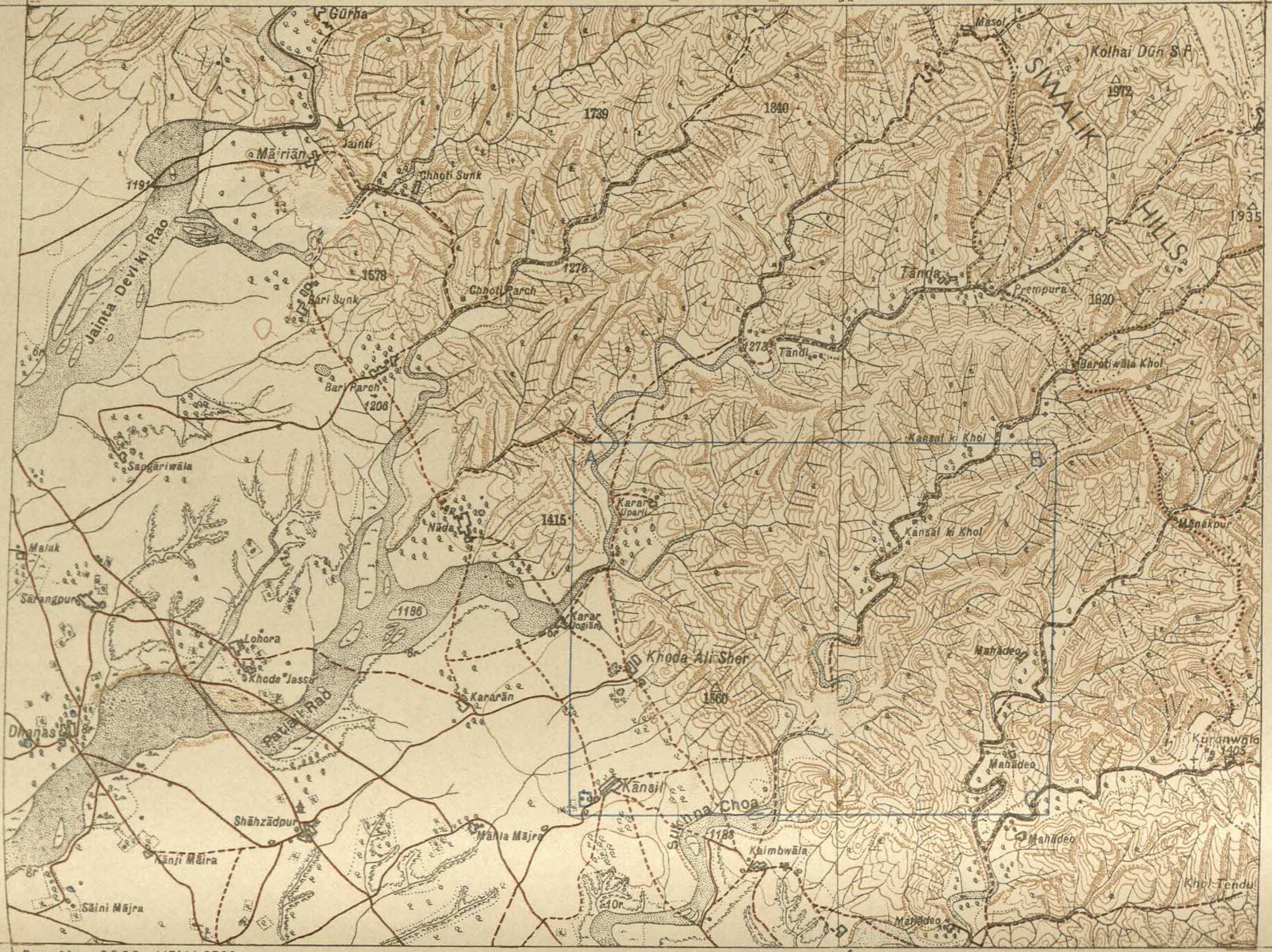
Plate 9-A : Aerial photograph of the area marked A B C D in plate 9. Locate the water reservoir, the railway line and the road in the photograph. Do you see the Dilwara Village in the photograph? (*Scale* : 2 inches = 1 mile)

Plate 10

SIWALIK HILLS IN AMBALA DISTRICT

Part of Sheet No. 53 B/13



Reg. No. 8802 HE'66-2500.

45 E. of GREENWICH.

Scale 1"=1 Mile.

CONTOUR INTERVAL 50 FEET

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Plate 10-A **: Aerial photograph of the area marked A B C D in plate 10. Note the two distinct topographic features—hills and a flat lowland lying in the south-western corner. Study carefully the drainage of this area. Can you see the villages Kansil and Khoda Ali Sher in the photograph? (*Scale* : 2.53 inches=1 mile)**

course, on a very small scale and is true only locally.

What vegetation do you find in this area? The wooded area on the western hills is limited in extent. Why is it so?

The region is fairly well served with modern means of communication. Discuss the influence of relief on the roads and railways in this area. What physical features are followed or avoided by a route in order to maintain the most even gradient? Draw a cross-section along a line joining Sardhna and Chang villages and mark the positions of the railway line and the road on the profile.

Beawar (Nayanagar) is the only urban centre in the entire region. It draws upon the agricultural resources of the surrounding country. How far is it from its old site? Is it a major route-centre? How many and how important are the routes which meet here? How big is the settlement? Compare the sites of Beawar and Beawar Nayanagar. Find out the latitude and longitude of Beawar Nayanagar and locate it on the map of India.

Except Beawar (Nayanagar), the settlements are rural in character. These rural settlements are of two types—the scattered huts and the compact villages. Study carefully the general pattern of the distribution of population. Is it dense or sparse?

SIWALIK HILLS IN AMBALA DISTRICT

This is a portion of a sheet No. 53 B/13. It represents a part of Ambala District. The hills which occupy most of the region shown on the map are a part of Siwalik Hills, the foot-hills of the Himalayas.

Note the latitudinal and longitudinal extent of the region and locate it in relation to Chandigarh.

Find out the maximum and minimum heights shown on the sheet. In what direction is the general slope of the land? How would you divide the region into major physical units?

Observe carefully the highly dissected nature of the hilly area. How high are the hills from the base? How steep is the slope of these hills? Do you notice any escarpments in the area? Where are they found? Give a few examples.

Mark the narrow but flat valley bottoms with meandering streams. Sukhna Choa and the main tributaries of Patiali Rao are good examples of these streams.

Notice that all the major streams are almost parallel to one another flowing from north–east to south-west across the ridge. All the streams appear to be busy in headward erosion pushing back the water divide. Observe carefully the streams that extend up to the eastern and north-eastern margins of the sheet.

Study carefully how the nature of the streams changes as soon as they descend on the plain. How would you account for the sudden widening of the river-beds, their braided course and the formation of islands in their channels? Note the gullies or the ravines along the streams in the plain. This indicates that the plain consists of alluvium deposits brought down by the rivers from the Siwalik Hills.

Note that there is very little vegetation even in the hills. This is another indication of how badly eroded the hills are.

Do you see any metalled roads in this area? Even the cart tracks are confined to the south-west part of the region which is a plain or a valley bottom. Note the camel tracks along the foot of the hills. Similarly, the camel tracks may be found in the hills but only along the river-beds. There is only one foot-path in the hills.

The important village settlements are in the plain and along the foot of the hills. These settlements are compact but far apart indicating the relative poverty of the region. The settlements in the hills consist of scattered huts and those too are extremely sparse. There is not a single town in the entire region.

PINJAUR : A VALLEY IN THE SIWALIKS

This plate is in continuation of the previous one as it represents an adjoining area in the east. The map represents a tract lying to the north-east of Chandigarh. A valley in the Siwalik Hills is the important feature of this sheet.

Note the latitudes and longitudes of this area to locate it, on a map of India in relation to the previous sheet. Find out the total area of the region represented on the sheet.

Into how many physical units would you divide this region and how would you name them? Draw a cross-section along a line joining the north-east and south-west extremities of this sheet. Show the locations of a railway line, a metalled road, the river channel and the forests on the profile.

Describe the crest line—its trend and the heights of its peaks—in the south–western part of the area. Compare the slopes on the two sides of this line. Would you call this line a watershed? If so why ?

How do the hills in the east differ from those in the south-west? Find the highest elevation shown on the map. Note the triangulation stations on the peaks of some of the hills.

Study carefully the profile of the valley of Jhajra Nadi. It presents a good example of an asymmetrical valley, i.e., one of the valley sides being very steep as compared to the other. Which side of this valley is very steep? How gentle is the slope of the other side? Note that all the important tributaries of this river are flowing from the eastern hills.

Note the seasonal character of these streams including the Jhajra. Yet they must be carrying a large amount of water during the rainy season. What makes you think so?

When these hill streams are active in the rainy season, their field of activity is not confined merely to carrying water. They are responsible for land erosion on a very large scale. What symptoms of land or soil erosion do you notice on this sheet?

Note the gullies and ravines carved out by the streams along the southern margin of the sheet. Observe carefully the presence of islands in the channel of the Jhajra and its tributaries. How would you account for their presence?

Another interesting feature of the drainage is the braided channel of Koshallia Nadi. It further suggests that the hill streams carry a large load with them which they deposit on their bed when the velocity of water slows down owing to the low gradient of the river.

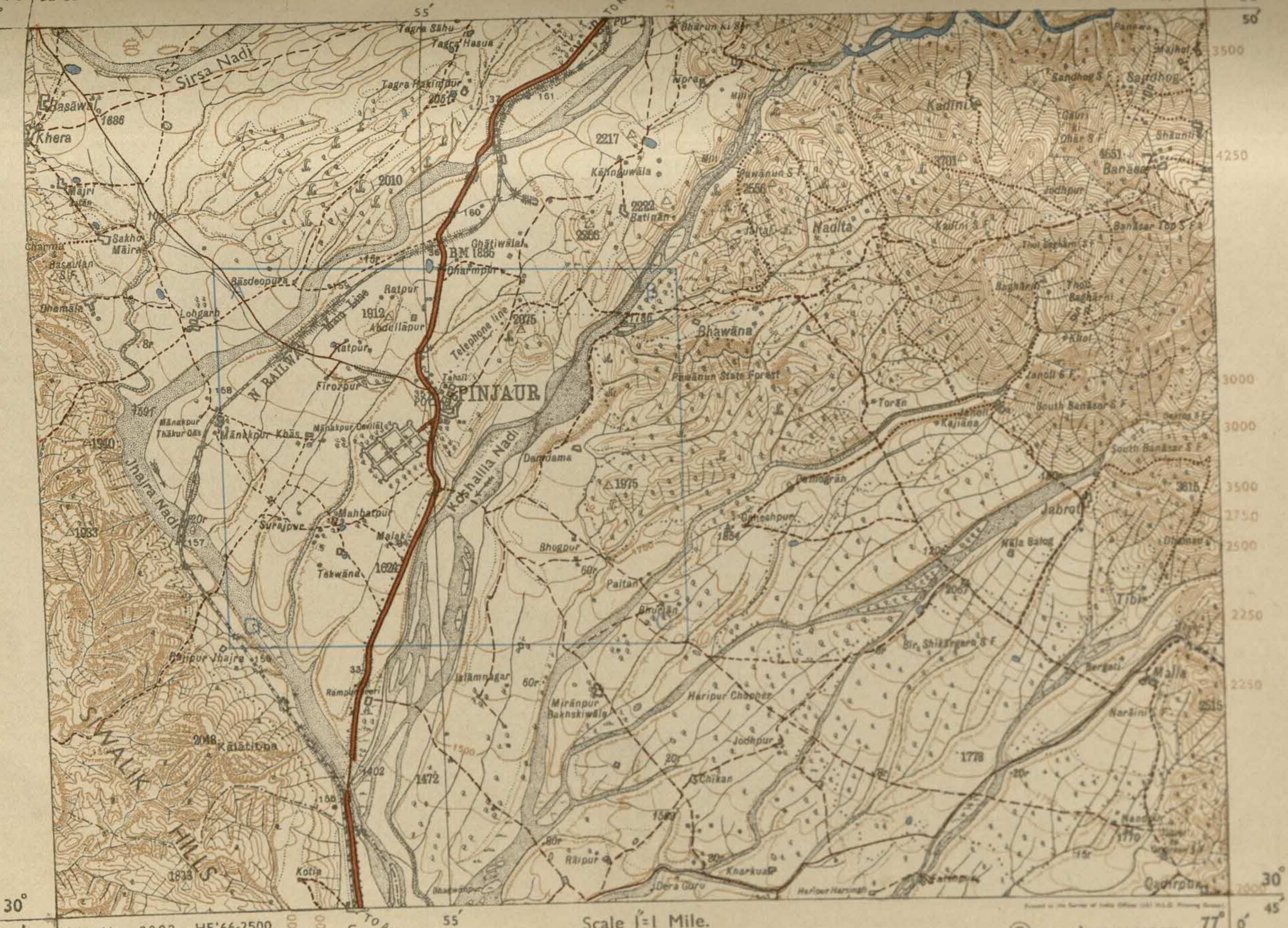
The river Koshallia is only a seasonal stream in its lower course. In its upper course, however, it is a perennial stream. How would you explain this phenomenon? Study carefully the area where a perennial stream gives place to a non-perennial one. Mark the streams that disappear instead of joining the Koshallia Nadi down below. This indicates the presence of alluvial fans in this area where water sinks down the sand. This explains how a perennial stream in the hills suddenly becomes only a seasonal stream on entering the plain.

What vegetation do you find in this area? Note the reserved and state forests.

Describe the lines of communication in this area. Do you think that they are meant to serve the local needs? Correlate the main lines of communication with the relief features.

The presence of a fort-cum-palace at Pinjaur explains its historic importance and the picturesque location. Pinjaur is the only town in this area. It seems that it grew because of the palace. Would you call it a collecting and distributing centre of the area?

But for a few villages, the settlements are mostly in the form of scattered huts. There are a few settlements in the valley. But they generally avoid being close to any river. There are quite a few villages in the forested



TO Ambala Cantonment 31 m.

Reg. No. 8802 HE'66-2500.
52' 30" E. of GREENWICH.

Scale 1"=1 Mile.
CONTOUR INTERVAL 50 FEET.

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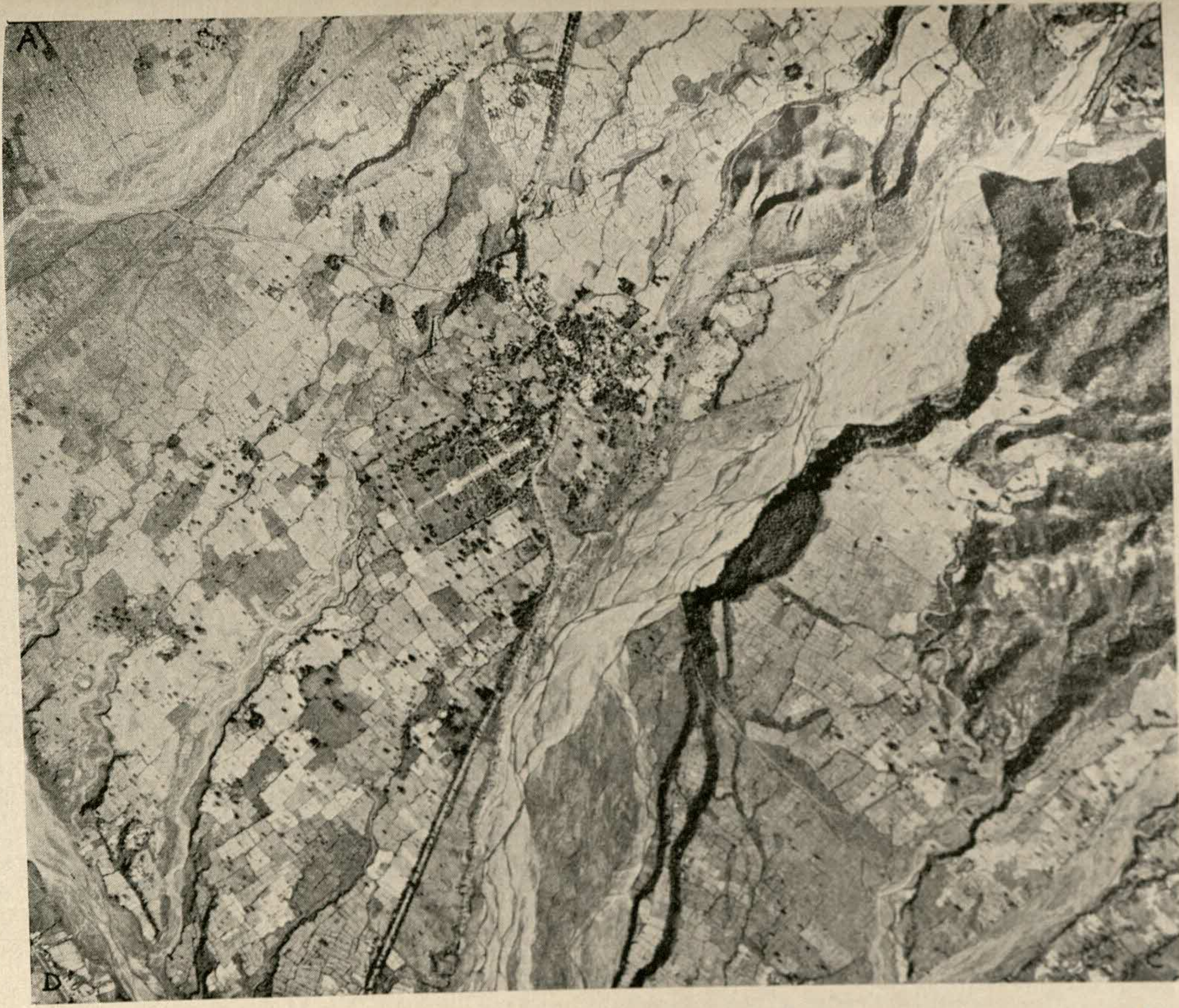

Plate 11-A : Aerial photograph of the area marked A B C D in plate 11. Note the Pinjaur town and the fort containing gardens. Do you see the forested hills, a railway line and a metalled road ? (*Scale* : 2.53 inches=1 mile)

hills of the east. Do you think that the people in this area prefer to cling to the hillside rather than to the valley bottom? If so, why? Observe a large number of camel tracks and foot-paths in the hills. Are the forest resources important in this region?

EXERCISES

Review Questions

1. Answer the following questions:
   (*i*) What are the different types of maps?
   (*ii*) What is meant by "setting a map"?
   (*iii*) How does a cadastral map differ from a topographic map?
   (*iv*) Explain what map interpretation is.
   (*v*) What are the common headings under which a topographic sheet is interpreted?

2. Write short notes on:
   (*i*) Wall maps;
   (*ii*) Marginal information;
   (*iii*) Topographic sheets;
   (*iv*) Relief maps.

3. Discuss the statement: "Today more and more people are becoming increasingly map conscious."

4. If you are studying a topographic sheet depicting some urban settlements, what information would you like to seek from the map? What specific questions would you raise to draw precise information?

5. Fill in the blanks with appropriate words:
   (*i*) The common symbols including letters that are used for representing various relief and cultural features are called............
   (*ii*) Once we find out the............North we can easily locate True North if we also know the........ ....
   (*iii*) Maps are classified on the basis of their............ and their.........
   (*iv*) The atlas maps are............scale maps.
   (*v*) The............maps provide us information regarding temperature, pressure, ...winds and............

Map Reading

6. Study carefully the sheets given in the text and answer the following questions:

   (*i*) With the help of the scale given on the map, measure the actual distance between the two meridians of longitude 5′ apart as shown on the Arani sheet. Do the same for the Pinjaur sheet and compare your results. What inference would you draw from this?

   (*ii*) Compare the terrain represented on the Ulhas Valley sheet and Ponneri sheet. How do they differ?

   (*iii*) How do the river valleys of the Ulhas, the Ganges and the Jhajra Nadi as shown on the three different sheets differ from one another?

   (*iv*) Compare and contrast the means of communication as shown on the Kalyan sheet and the Mirzapur sheet.

   (*v*) In what ways are the settlements in the Aravalli sheet different from those in the Mirzapur sheet?

7. Draw yourself the conventional symbols for the following;

   (*i*) Tidal limit; (*ii*) Steep river banks; (*iii*) A railway tunnel; (*iv*) Perennial tank; (*v*) Bamboos; (*vi*) A waterfall; (*vii*) A ferry service; (*viii*) Pontoon Bridge; (*ix*) Orchards; (*x*) Scattered huts; (*xi*) Lined wells; and (*xii*) Ravines.

Films Available

Maps Are Fun. No. 912; 11 mins; English; D. A. V. E.

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CHAPTER 6

Weather Study

WEATHER STUDY is a subject of universal interest. The vagaries of weather have been man's concern for countless years. Till recently his observations of weather phenomena were haphazard. They were no more than mere personal impressions. The occurrence of a storm, rain or drought always left him wondering and guessing. It is only recently that he has been able to get fairly close to the secrets of weather by measuring atmospheric conditions with precision and recording his observations in a systematic way. Such systematic measurements and observations were possible only after the invention of instruments like the *thermometer* and the *barometer*.

There are a number of atmospheric conditions that can be measured with a fair degree of accuracy. The important ones are (i) temperature, (ii) pressure, (iii) winds, (iv) humidity, (v) cloudiness, and (vi) precipitation. These are the basic *weather elements*. A change in one weather element will in turn, change the others. Sometimes, one element may be more noticeable than the others. Hence, on the basis of a predominant weather element, weather conditions can be generalized by referring to them as 'rainy', 'sultry', 'cloudy', 'windy', or 'sunny'.

Weather forecasts help us to take safety measures in advance in case of the likelihood of bad weather, viz., storms, gales, and heavy downpours. For instance, predicting weather a few days in advance may prove very useful to farmers and to the crews of ships. Similarly, prediction of weather only a few hours ahead may facilitate safe air flights. This is, at any rate not a simple task. To do it accurately, the weatherman requires a number of weather instruments devised specially for the purpose. He needs to know how to use these instruments. He also requires weather information from neighbouring regions.

This chapter deals with the description and use of some of the common, but important, weather instruments.

Measurement of Temperature

The knowledge of the temperature of the freely moving air is the primary concern of the weatherman because it is responsible for a variety of weather changes. The instrument designed to measure accurately the changes of temperature is called a *thermometer* which literally means 'heat measurer'.

The construction of a thermometer is based on the fact that any substance, whether solid, liquid or gas, expands in a particular manner when heated. Gases expand the most and are, therefore, most sensitive to heat; but at the same time, such a thermometer would be too bulky and, therefore, unwieldy. Consequently, liquids are preferred as liquid thermometers are smaller and easier to read and handle. They are the most common type of thermometers for making surface weather observations. Ordinarily, mercury or alcohol are used as the *thermometric liquids* in standard thermometers.

A thermometer consists of a narrow sealed glass tube of a small uniform bore sealed at one end and with an expanded bulb at the other. The bulb and the lower part of the

tube are filled with mercury. Before the other end is sealed off, the air in the tube is evacuated by heating it. The bulb of the thermometer in contact with the air gets heated or cooled, as the case may be, as a result of which the mercury in the bulb rises or falls. The change in atmospheric temperature is indicated by the rise or fall in the level of mercury.

There are two *fixed points* marked on the stem of the glass tube. The lower one, immediately above the bulb, indicates the position where the mercury level would be when the bulb of the thermometer is immersed in a vessel containing melting ice and hence shows the temperature of melting ice. Similarly, the upper end of the stem indicates the temperature of boiling water under normal conditions of pressure.

The length of the stem between the established boiling and freezing points is divided into equal divisions called *degrees*. The number of these graduations depends upon the nature of the scale used. The two most common *thermometer scales* in use are the *Centigrade* and the *Fahrenheit* (Fig. 45).

On the Centigrade thermometer, the temperature of melting ice is marked 0°C. and that of boiling water 100°C., and the interval between the two is divided into 100 equal parts. On the Fahrenheit thermometer, the freezing and boiling points of water are graduated as 32°F. and 212°F.* respectively and the interval between them is divided into 180 equal parts.

Thus the difference between the two fixed points on the Centigrade scale is 100 degrees, whereas on the Fahrenheit scale, it is 180 degrees. Therefore, one Centigrade degree is equivalent to 1.8 Fahrenheit degrees.

In order to change Centigrade readings to Fahrenheit, Centigrade degrees are multiplied by 1.8 (or by 9/5) and 32 is added to it because the freezing point on the Fahren-

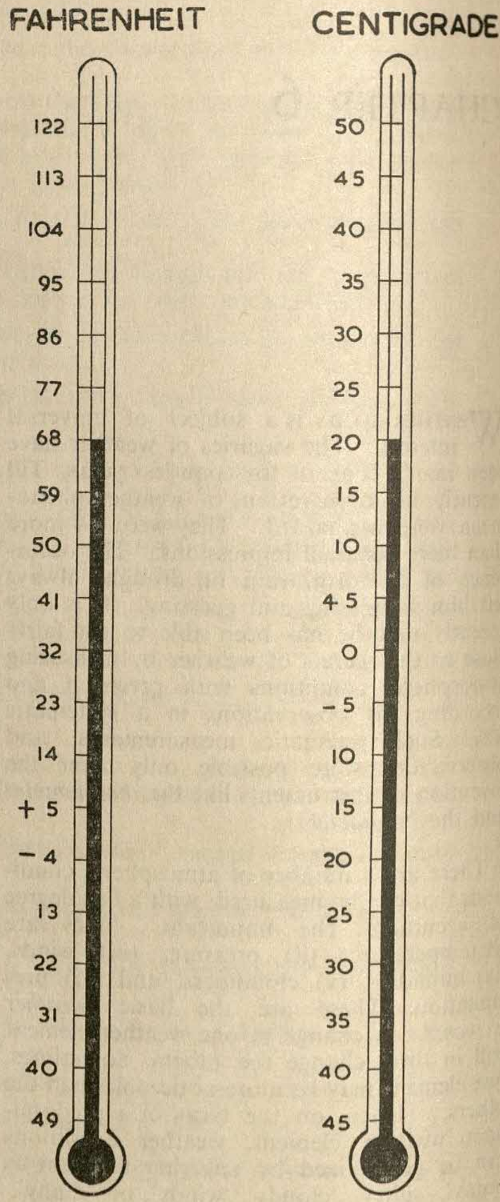


Fig. 45. Thermometers

The Fahrenheit thermometer was invented in 1710 by Daniel Fahrenheit, a German physicist. The Centigrade thermometer was invented in 1742 by the Swedish astronomer, Anders Celsius. What is the advantage in adopting the Centigrade scale?

* 0° in the Fahrenheit thermometer coincides with the level of the mercury in the tube when the bulb is surrounded not by pure melting ice, but by a mixture of ice and salt. It was then graduated upwards and found that the temperature of melting ice was 32°F. and that of boiling water, at normal atmospheric pressure, was 212°F. This is how the Fahrenheit scale originated.

heit scale is 32 degrees. On the other hand, to change Fahrenheit readings into Centigrade, the process is reversed, i.e., 32 is first subtracted and the balance is then divided by 1.8 (or multiplied by 5/9). The following formula may be used for conversion from one scale to another:

(*i*) From Centigrade to Fahrenheit;

$$F=(C\times 9/5)+32.$$

(*ii*) From Fahrenheit to Centigrade;

$$C=5/9\ (F-32).$$

Example:

The normal temperature of the human body is 36.9° C. Convert it to Fahrenheit.

$$\begin{aligned} F &= (C\times 9/5) + 32 \\ &= (36.9\times 9/5) + 32 \\ &= 66.4 + 32 \\ &= 98.4^\circ F. \end{aligned}$$

There are special thermometers that register maximum and minimum temperatures and also wet and dry temperatures.

Six's Maximum and Minimum Thermometer

The purpose of a maximum and minimum thermometer is to record the highest and the lowest temperatures occurring during a given period. A record of the maximum and minimum temperatures in a given period is kept by the instrument itself (Fig. 46).

Six's Maximum and Minimum thermometer consists of a cylindrical glass bulb A, connected to a U-tube BC which terminates in another bulb D as shown in the figure. The lower part of the U-tube BC contains mercury. The parts of the limbs B and C above the mercury surface and the bulbs A and D contain alcohol as the thermometric liquid.

Above the mercury surface in each limb, there are two steel indices I_1 and I_2, each provided with a spring arrangement which keeps them pressed to the sides of the tube. To set the thermometer, each index is moved up

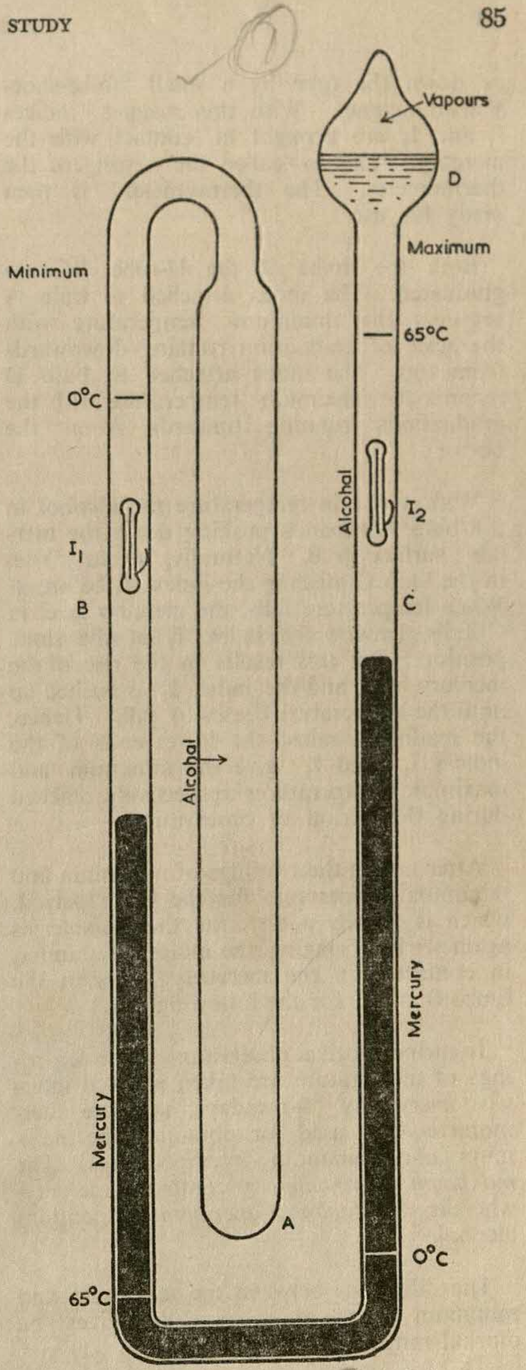


Fig. 46. The Principle of Six's Maximum and Minimum Thermometer

It saves man the trouble of keeping a constant watch on the instrument to note the highest and the lowest temperatures during a given period, say 24 hours. How is it possible?

or down the tube by a small horse-shoe-shaped magnet. With this magnet indices I_1 and I_2 are brought in contact with the mercury. This is called the setting of the thermometer. The thermometer is then ready for use.

Both the limbs of the U-tube BC are graduated. The index attached to bulb A registers the minimum temperature with the scale of graduation running downwards from top. The index attached to bulb D records the maximum temperature with the graduations running upwards from the bottom.

With a rise in temperature the alcohol in the bulb A expands pushing down the mercury surface in B. Naturally, mercury rises in the limb C pushing the index I_2 before it. When temperature falls, the mercury level in C falls, leaving the index I_2 at the same position. But this results in the rise of the mercury in B, and the index I_1 is pushed up until the temperature ceases to fall. Hence, the readings against the lower ends of the indices I_1 and I_2 give the minimum and maximum temperatures respectively reached during the period of observation.

After noting the readings of maximum and minimum temperature for the given period, which is usually a day, the thermometer is again set by bringing the indices I_1 and I_2 in contact with the mercurry levels in the limbs B and C for the following day.

In meteorological observatories, the recordings of temperature are taken at fixed intervals every day. Nowadays, separate thermometers are used for obtaining the maximum and minimum temperatures. The *maximum thermometers* contain mercury, whereas the *minimum thermometer* contains alcohol.

The difference between the maximum and minimum temperatures of a day gives the diurnal range of temperature.

The mean daily temperature is the mean of 24 readings taken at hourly intervals. This is almost the same as the average of the three readings taken at 6 a.m., 1 p.m. and 6 p.m. or the average of the three readings at 7 a.m., 2 p.m. and 9 p.m. The mean of the maximum and minimum temperatures of a day does not give the mean daily temperature and is generally larger than the mean of the hourly readings.

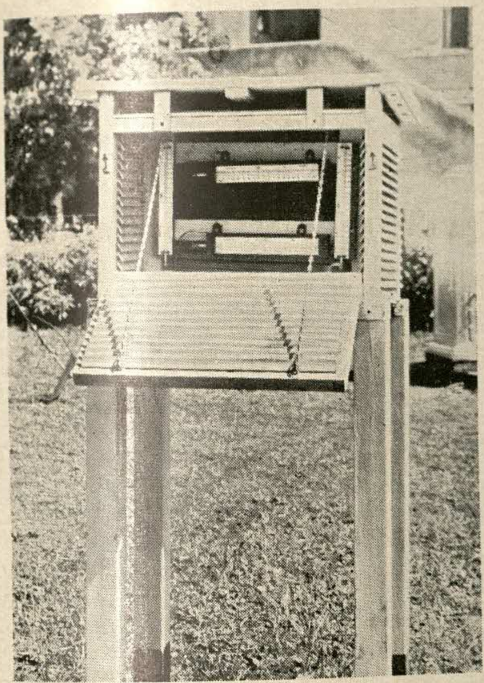
Wet and Dry Bulb Thermometer

It consists of two exactly identical thermometers fixed to a wooden frame. The bulb of the thermometer T_1 is kept uncovered and is exposed to the air while the bulb of the thermometer T_2 is wrapped with a piece of wet muslin or cotton which is kept continuously moist by dipping a strand of it into a small vessel of water as shown in Fig. 47. When air blows over the instrument, the water from the wet bulb evaporates. The evaporation from the wet bulb lowers its temperature. Hence T_2 will record a lower temperature than T_1.

Dry bulb readings are not affected by the amount of water vapour present in the air but the wet bulb readings vary with it, since the rate of evaporation is dependent upon the amount of water vapour present in the air. The greater the humidity of the air, the slower the rate of evaporation and hence the difference between the readings of T_1 and T_2 will be small. On the other hand, when the air is dry, the evaporation from the surface of the wet bulb is rapid, which would lower its temperature and the difference between the two readings would be large. Hence the difference of the readings of T_1 and T_2 determines the state of the atmosphere with regard to its humidity, the larger the difference the more arid the air is. Exact humidity can be determined by reference to specially prepared tables.

For correct wet and dry bulb readings, the vessel should be kept filled with distilled water. Care should be taken to change the muslin, at least once a month. When the weather is damp, the dry bulb thermometer should be wiped dry a few minutes before the time of observation.

The thermometers should be exposed neither to direct sunshine nor to reflected radiant heat. They are generally housed in a *shelter*, a double-walled cubical wooden box painted white. It has louvred sides,

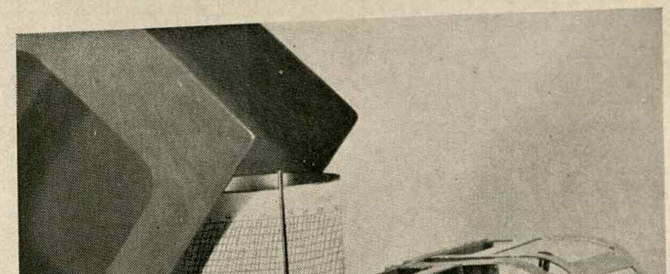


While permitting free movementof air through its louvred sides, it protects the instruments from direct sun rays. Why are huts preferred as shelters in tropical countries ?

A Shelter

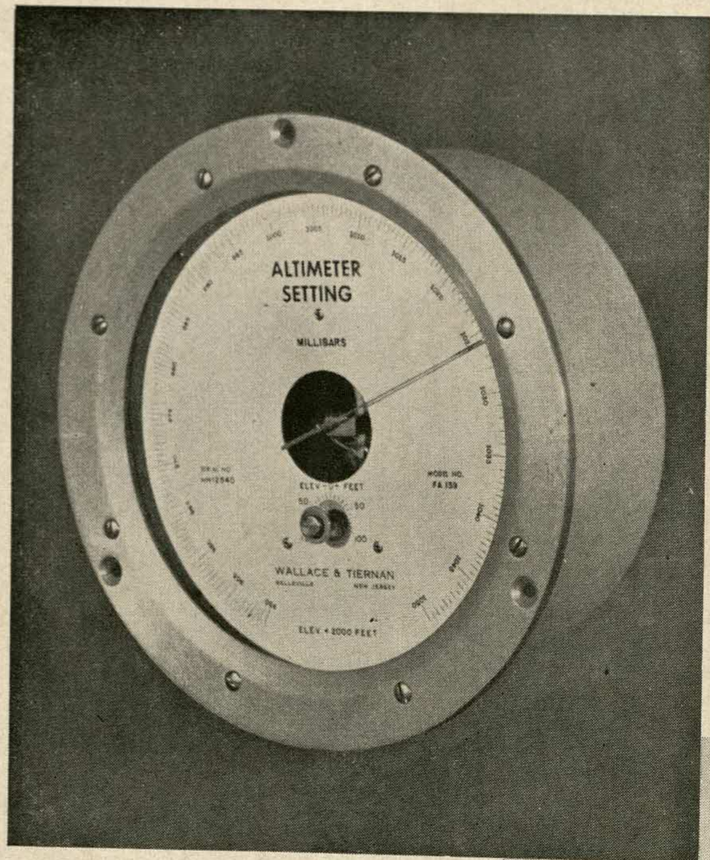
(Courtesy: India Meteorological Deptt.)

This is a self-recording instrument providing a continuous and a graphic record of temperature for a period of a week at a stretch. What do you think is the function of a cylinder round which the graph paper is wrapped ?



A Thermograph

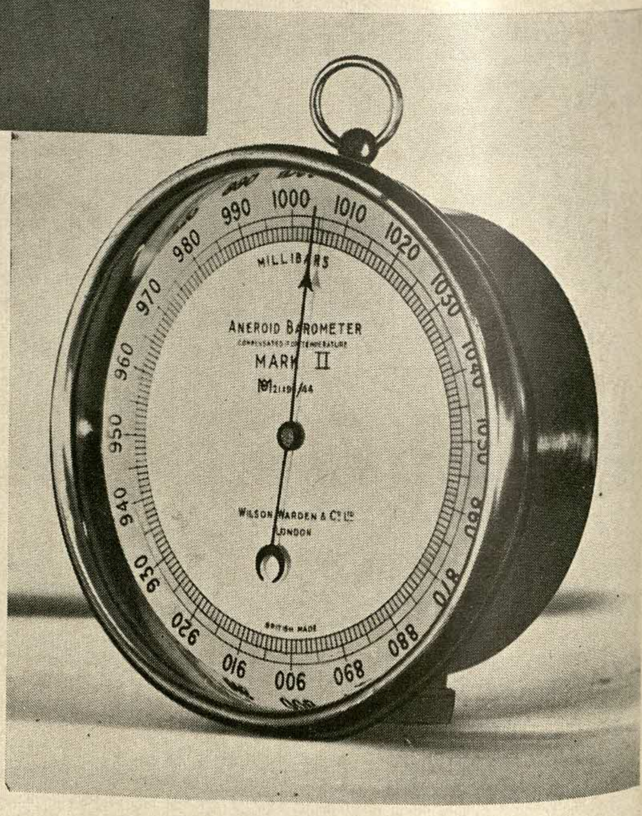
(Courtesy: India Meteorological Deptt.)



An Altimeter

(Courtesy: India Meteorological Deptt.)

This instrument is very useful for air pilots and mountaineers as it helps to read the heights directly from the dial. How does it differ from a simple aneroid barometer?



An Aneroid Barometer

(Courtesy: India Meterological Deptt.)

Although less accurate than the mercury barometer, it helps to read the pressure at a place directly from the dial. Why is this instrument not very accurate?

that is, open windows crossed by a series of sloping boards to permit free movement of air without direct passage of the solar ray. It is kept at a height of about a metre and placed away from buildings, in an area not enclosed by walls or trees. This type of shelter is in common use in meteorological stations in most parts of the world. In tropical countries, however, where heat is intense, huts with thatched roofs and open sides are generally preferred as shelters.

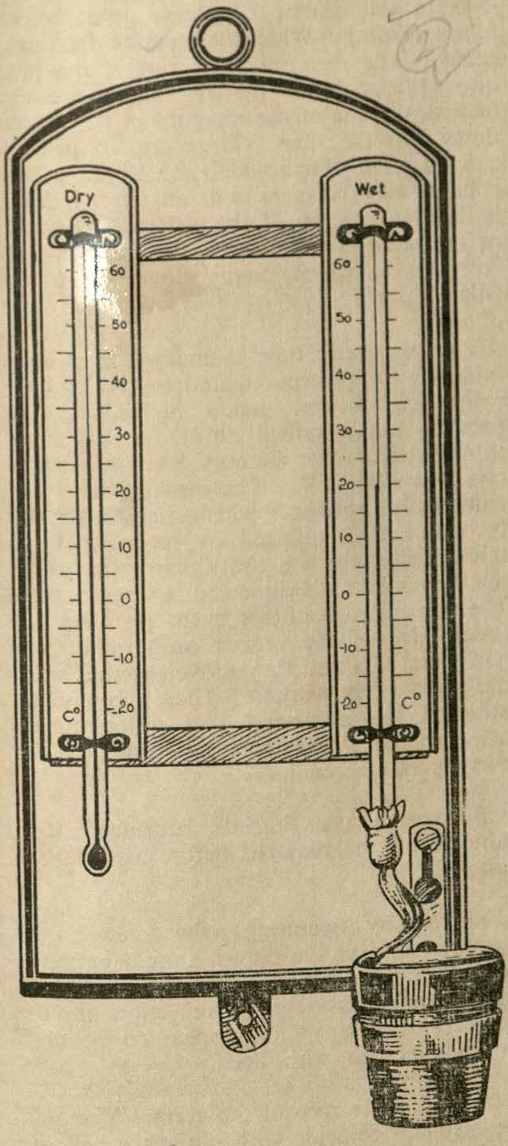


Fig. 47. A Wet and Dry Bulb Thermometer

The difference of the readings of T_1 and T_2 determines the state of the atmosphere with regard to its humidity. The lesser the difference the more humid the air is. How does this instrument help us in knowing about our daily weather?

Measurement of Atmospheric Pressure

It is well known that air has weight, and that it exerts great pressure on the earth's surface. It has been found that at sea level, under normal conditions, the pressure of air is 14.7 lb. on every square inch or 1.03 kg. per square centimetre. As a result of the constant movement of air, the changes in temperature and the variation in its vapour content, the weight of the air above any point is continually changing. Therefore, like temperature, atmospheric pressure also varies with time and place. Although its variations are not so easily perceptible to the human senses, it is an important feature of weather study and forecasting, because of its close relationship with other weather elements.

The instrument designed to measure atmospheric pressure is called a *barometer*. The principle of a mercurial barometer is explained by a simple experiment. Take a thick glass tube of uniform bore about a metre long and fill it with mercury. Close the mouth of the tube with a finger, then invert and immerse its open end in a cup of mercury without allowing air to enter in the tube and then remove the finger. The mercury will flow out of the tube into the cup and stand at a definite height above the level of the liquid in the cup. This is because the weight of the column of mercury in the tube, above the surface of the mercury in the cup, is balanced by the weight of the air column of an indefinite height exerted as pressure upon an equal cross-section of the liquid surface. The height of the column of mercury in the tube, therefore, becomes the measure of the pressure of air. The height of the column is graduated in millimetres or in inches (Fig. 48).

Fortin's Barometer

Like the simple barometer, the Fortin's barometer consists of a vertical glass tube

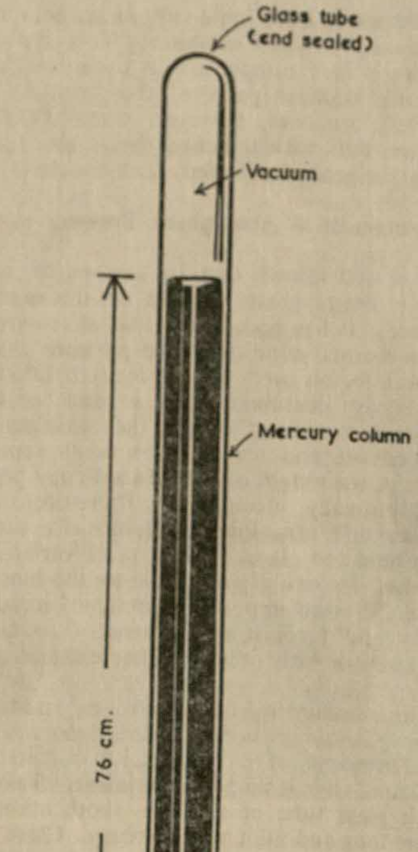


Fig. 48. A Mercurial Barometer

It was invented by Torricelli, an Italian physicist, in 1643, to measure atmospheric pressure. What is the principle on which a mercurial barometer works?

containing mercury, the upper end of which is closed and the bottom open. The open end of this tube is inverted into a cistern of mercury. The cistern has a flexible bottom with an adjusting screw S to bring the mercury level in the cistern to a fixed point before taking readings. When the pressure decreases, some of the mercury flows out of the tube into the cistern. When the pressure increases, some of the mercury in the cistern flows into the tube. Therefore, to provide a fixed point above which the height of the column may be measured, an ivory index I is fixed to the top of the cistern. The zero of the scale corresponds to the tip of the ivory index which points down vertically (Fig. 49).

The barometer tube is encased in a brass tube AB for protection, and the scales indicating centimetres, inches or millibars of pressure are inscribed on it. It has a slit through which the mercury level in the tube can be clearly seen. The instrument is provided with a vernier V which slides in the slit. Its position is adjusted by means of the screw T. There is a brass plate attached to the vernier and is behind the barometer tube. The lower edge of this brass plate and the lower edge of the vernier are in the same horizontal line and they move together when the screw T is worked. There is also an attached thermometer. This thermometer helps to make a temperature correction for every pressure reading.

For using the Fortin's barometer, two adjustments are required before a reading is taken.

Firstly, by operating the screw S the mercury level in the cistern should be made to just touch the tip of the ivory index I, and its image as seen by reflection at the mercury surface should appear to be in a continuous line with itself.

Secondly, the zero of the vernier V should be made to coincide with the surface of the mercury in the tube. For this, the eye is kept in level with the horizontal line joining the lower edge of the vernier V and the brass plate behind it. The screw T is worked until the top of the mercury in the tube is in the same line as the lower edge of the brass plate

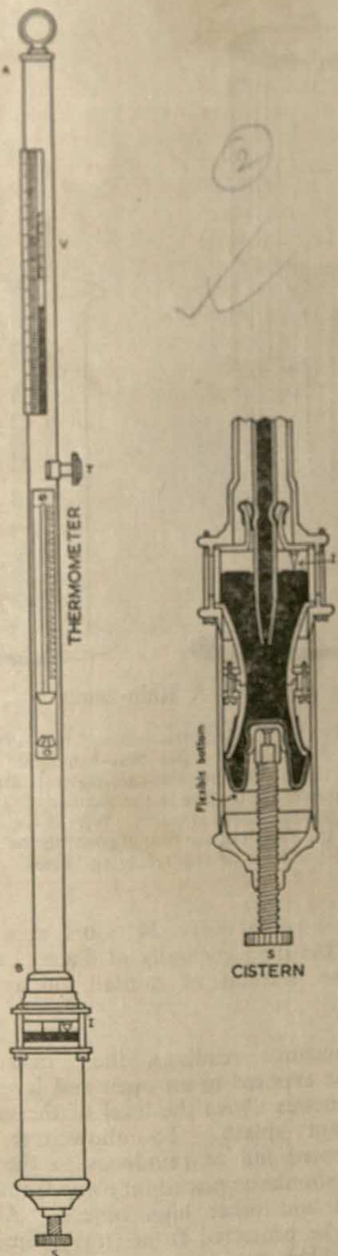


Fig. 49. Fortin's Barometer *(Adopted from F. A. Barry; E. Bolla : and N. R. Beers.)*

This barometer is capable of recording accurate atmospheric pressure. It is, however, a heavy instrument and cannot be easily transported. How does it differ from a simple mercurial barometer?

and the vernier. The barometer is then ready for taking observations.

Aneroid Barometer

Another instrument in common use for the measurement of atmospheric pressure is the *aneroid barometer*. It gets its name from the Greek word *aneros (a—*'not', *neros*-'moisture') meaning without liquid.

It consists of a corrugated metal box made of silver or some similar thin alloy, sealed completely and made air-tight after partial exhaustion of air. It has a thin flexible lid which is sensitive to changes of pressure. There is a spring inside the box which keeps the lid from collapsing under the pressure of the atmosphere and restores the shape when the pressure is reduced.

As the pressure increases, the lid is pressed inward and this in turn moves a system of levers connected to a pointer which moves clockwise over the graduated dial giving higher readings. With the decrease in pressure, the lid is pushed outward and the pointer moves counter-clockwise, indicating the lowering of barometer reading.

Generally the aneroid barometer is not corrected for temperature and the pressure at a place is read directly from the dial. This barometer, however, is less accurate than the mercury barometer. It is light and portable and is, therefore, suitable for explorers, mountaineers and travellers and is frequently used by ships on the high seas.

The relationship between atmospheric pressure and the height of a place above sea level can easily be explained. The atmospheric pressure is maximum at sea level since the column of air which stands on it is the largest. As we move up above sea level, the height of the column of air gradually diminishes, and as a result of this the atmospheric pressure is reduced and the barometer shows a lower reading.

Furthermore, since air is a compressible substance, the lower layers are more compressed and, therefore, denser than the upper layers. Thus a pressure reading taken at a higher level will exclude the densest layer

of air which occurs below, and as a result of this, the reading will be less than at the bottom of the layer. These facts are of special significance in aviation and mountaineering.

An *altimeter* is a special type of aneroid barometer which is a standard equipment for air pilots and mountaineers. It is graduated to read heights directly.

It has been observed that the normal atmospheric pressure at sea level is equal to the weight of a column of mercury 76 centimetres long. Pressure diminishes with increasing heights in arithmetic progression. That is, on an average, a fall of one centimetre in barometer level indicates an elevation of nearly 110 metres above sea level, another centimetre fall in pressure for a height of 115 metres and another for 120 metres and so on. This is readily observed in the first thousand metres of the atmosphere above the earth.

Measurement of Precipitation

For measuring the amount of rain which falls in a locality during any interval of time, a simple instrument called the *rain-gauge* is used. There are many types of rain-gauges, but the object of all is to collect the rain-water falling on an area and store it without allowing any loss by evaporation, run off, or seepage below (Fig. 50).

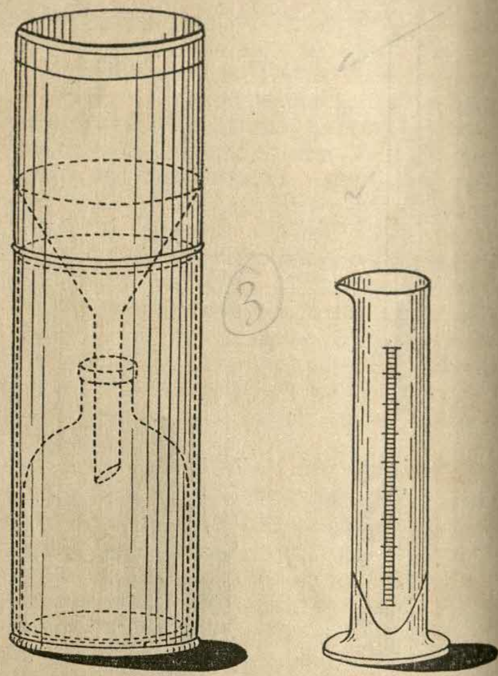


Fig. 50. A Rain-gauge

The object of rainfall measurement is to obtain the depth of the layer of water that has fallen over a period of time, assuming the rain-water to be evenly distributed over the surface in the vicinity of the area where the measurement is taken. Why is the circumference of the mouth of the funnel equal to the circumference of the base of the receiving vessel?

The rain-gauge consists of a metal cylinder in which a funnel (See Fig. 50) fits accurately and directs the rain into a receiving vessel. The circumference of the mouth of the funnel is equal to the circumference of the base of the receiving vessel. The mouth of the cylinder is 12.5 centimetres above the mouth of the funnel so as to avoid any splashing out due to the falling rain-water. Automatically all the rain-water that falls on the surface area of the funnel flows into the vessel.

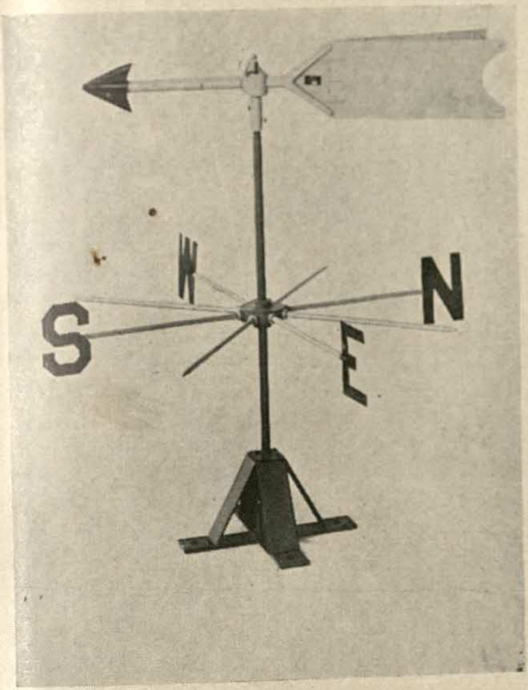
The water collected is measured by a measuring jar which is graduated either in millimetres or in inches. The area of the base of the measuring jar has a definite relationship with the area of the funnel. In India, we use millimetres or centimetres as the unit of measurement of rainfall. The reading is taken every 24 hours at a fixed hour of the day, generally at 8 a.m., and it shows the amount of rainfall on a given day.

For accurate readings, the instrument should be exposed in an open and level area 30 centimetres above the level of the ground to prevent splash. To allow free and unintercepted fall of raindrops in the rain-gauge, it should be placed far away from trees, buildings and other high objects. Also it needs to be protected from stray animals as they are likely to overturn the rain-gauge.

Wind Direction and Speed

Wind is another basic weather element. Two facts about wind need to be observed with care, namely, direction and speed.

4

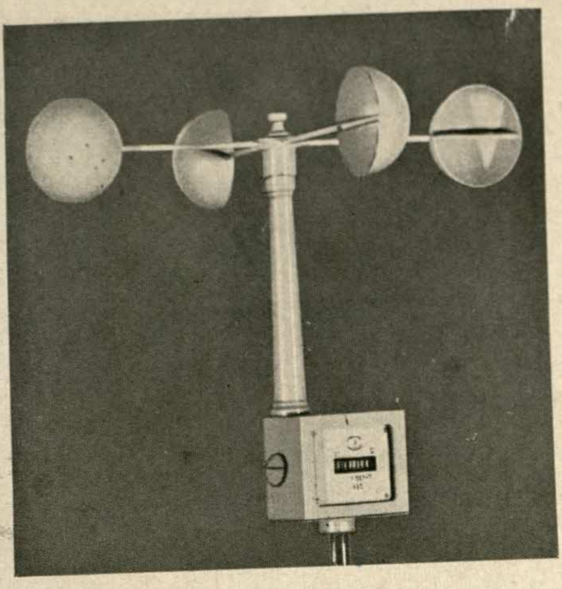


The arrow of the wind vane is always nosed into the direction from which the wind blows. How does the tail aid the arrow in pointing towards the source of the wind?

A Wind Vane

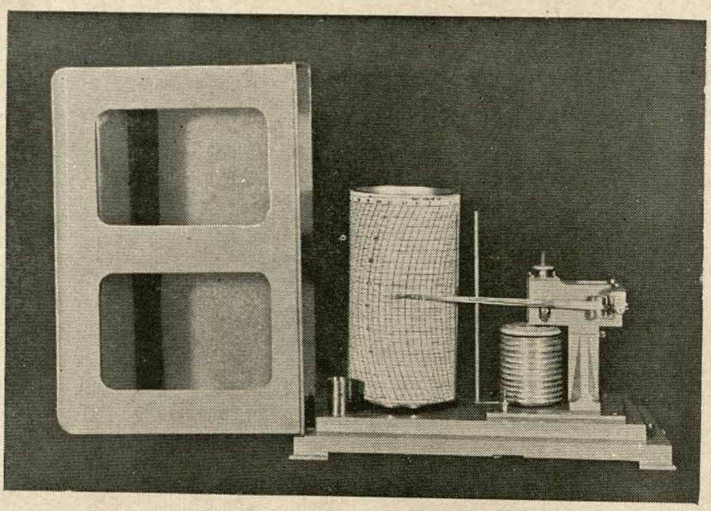
(Courtesy: India Meteorological Deptt.)

This is an instrument comprising a system of cups and a wind-speed indicator. How is wind-velocity measured by this instrument?



An Anemometer

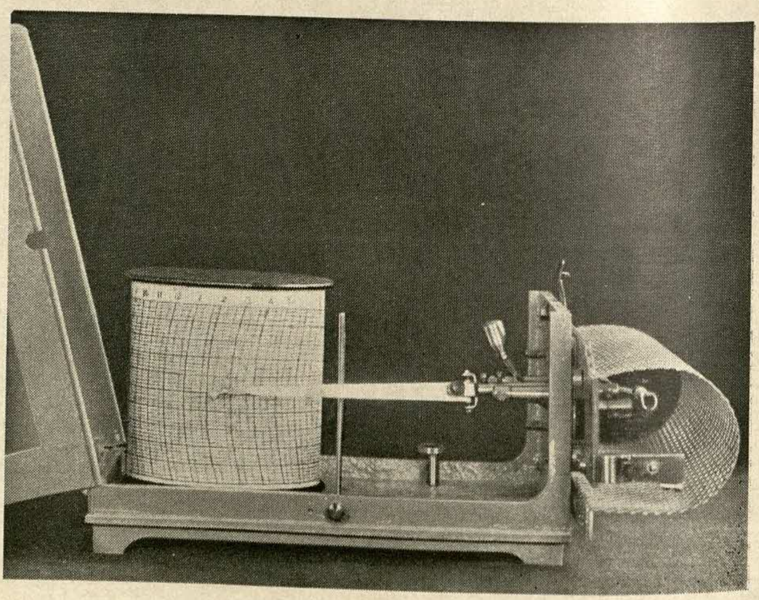
(Courtesy: India Meteorological Deptt.)



This instrument is an aneroid barometer which makes a continuous record of the changing pressure for a week. What advantage has a barograph over other barometers?

A Barograph

(*Courtesy: India Meteorological Deptt.*)



In this instrument the pen moves over a cylinder and makes a continuous record of the relative humidity for a week. What value has hygrograph as a weather forecasting instrument ?

A Hair Hygrograph

(*Courtesy: India Meteorological Deptt.*)

Wind Vane

The usual method of determining wind direction is by means of a *wind vane*. It consists of a vane, that is, a revolving plate. This plate is perfectly balanced on a rod. There are ball bearings on which it turns smoothly without friction, so that it responds even to a slight blow of wind. In its simplest form, the vane has a light thin metallic or wooden structure having a pointed end known as arrow (made of heavy metal) and a broad end called the tail.

The arrow always points towards the *direction from* which the wind blows and the tail aids in keeping the point of the vane *nosed* into, or towards, the source of the wind at all times even when there are gusts accompanied by frequent changes in the direction of the wind. Below the vane, the vertical rod carries a cross indicating the four directions, viz., North, East, South and West.

Anemometer

An *anemometer* is the instrument used for measuring the wind velocity. This 'wind-speed indicator' consists of three or, less commonly, four hemispherical cups attached by horizontal arms to a vertical spindle.

When the wind blows, the cups rotate making the horizontal arms spin with them. The rotary motion of the horizontal arms, in turn, causes the vertical spindle to rotate. The faster the wind the swifter the turning of the spindle. At the bottom of the spindle, there is a mechanical device which records the number of its revolutions, and hence the velocity of the wind.

The anemometer is sometimes electrically connected to a dial inside the weather station. This dial indicates the speed of wind in kilometres, or miles, or knots per hour.

The place of exposure of wind instruments should be free from the interference of local irregularities. The wind instruments should be placed far away and also fairly above the adjacent high objects. Exposures at airports or towers in the open are generally preferred.

Weather Maps

A weather map gives, at a glance, a generalized picture of weather conditions that exist over a considerable area at some particular instant of time.

To construct such a map is by no means an easy job. Hundreds of observers are engaged in recording *data* simultaneously on a uniform pattern. They are also aided by highly sensitive self-recording instruments. The data are then collected and sent to central and regional observatories by telegrams and telecommunication channels without loss of time. In the Central Observatory these data are processed and depicted on a map known as the weather map. This is what the weather services or meteorological organizations do with the help of a widespread network of their observatories.

A meteorological service in India was established in 1875 with its headquarters at Simla. After World War I, the Meteorological Department was expanded and its central office was shifted to Poona. The Indian Daily Weather Reports are published every day from this place (Fig. 51).

An Indian Daily Weather Report has a map of India which shows pressure distribution, wind direction and velocity, rainfall, sky conditions and weather phenomena affecting visibility. It is accompanied by a daily weather report containing a summary of weather conditions that prevailed on the previous day and a forecast for the next 24 hours. It further contains data recorded at important stations all over India, the wireless reports received from ships in the Arabian Sea and the Bay of Bengal and the upper air data regarding winds, temperatures and dew points for a few places. It is on the basis of these synoptic charts that the weather forecasts are made.

Meteorological Observatories

In India there are more than 350 observing stations grouped into five categories. At one end of the scale stand Class I observatories equipped with self-recording instruments such as a thermograph (for temperature), a barograph (for pressure) and a hygrograph

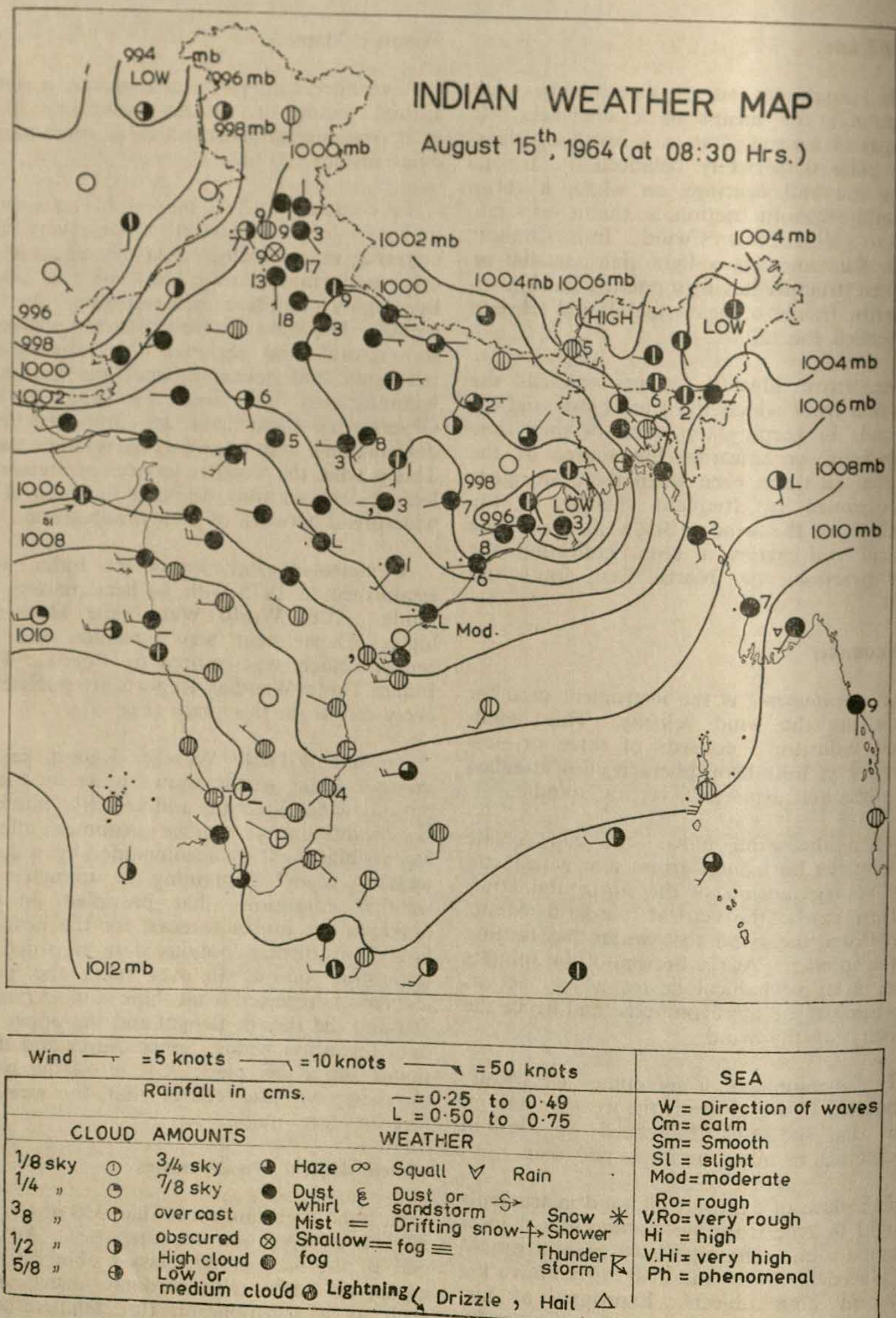


Fig. 51. An Indian Daily Weather Map *(After India Meteorological Department)*

This is a weather map that shows weather conditions in India and adjoining areas which prevailed at 0830 hours on August 15, 1964. Study carefully the symbols used in this map. What are lows and highs?

(for humidity). These observatories transmit data to the Central Observatory at Poona twice a day. At the other end of the scale are the Class V observing stations recording only the amount of rainfall, once every 24 hours. Besides these observing stations, valuable data are collected from the ships plying on the Indian seas.

The weather forecasts are highly useful for air pilots, navigators, fishermen, defence personnel, farmers, horticulturists, people connected with flood control and also the general public. It is for the benefit of all these people that weather bulletins are broadcast every day.

Man's concern for weather is perhaps as old as himself. The science of weather known as meteorology, however, came into its own rather recently with rapid advances in physics, mathematics, chemistry, geography, astronomy and mechanics. The invention of the barometer by Torricelli in 1643 and the thermometer by Fahrenheit in 1710 are important landmarks in its early development.

This science grew as a result of discoveries made by various scientists in their own fields. Even today, it is not an exact science. However, efforts are being made to break new ground. Establishment of observatories in Antarctica, the International Indian Ocean Expedition, the launching of rockets and weather satellites for collection of data from upper air and outer space, are some of the new landmarks in this direction.

EXERCISES

Review Questions

1. Answer the following questions:
   (*i*) Which are the basic elements of weather?
   (*ii*) How does an Aneroid barometer differ from a mercury barometer?
   (*iii*) Compare and contrast the Fahrenheit and Centigrade scales.
   (*iv*) Explain how relative humidity is determined.

2. Write short notes on :
   (*i*) A meteorological observatory;
   (*ii*) A shelter; and
   (*iii*) An Indian daily weather report.

3. Write in brief the story of an Indian daily weather map explaining the various stages involved in recording data, their collection at the central office, processing and depiction on a map.

4. In what different ways are the weather forecasts useful to different people?

5. Given below in the first column are certain functions to be performed and in

the other the instruments that are available with you. Make out correct pairs ignoring the instruments that are of no use to you.

(*i*) Finding out wind direction	(*i*) A thermograph
(*ii*) Automatic recording of pressure	(*ii*) Six's thermometer
(*iii*) Measuring velocity of wind	(*iii*) A hygrometer
(*iv*) Automatic recording of humidity	(*iv*) A hygrograph
(*v*) Finding out atmospheric pressure	(*v*) An altimeter
(*vi*) Taking the direct readings of heights	(*vi*) A barograph
(*vii*) Automatic recording of temperature	(*vii*) A wind vane
(*viii*) Finding out humidity	(*viii*) An aneroid barometer
(*ix*) Finding out maximum and minimum temperature for a given period	(*ix*) An anemometer
	(*x*) Wet and dry bulb thermometer
	(*xi*) Fortin's barometer

Collecting and Representing Climatic Data

Your class can collect a good deal of climatic data, maintain a systematic record and present it graphically.

See if you can ultimately come out with the graphs showing (*a*) mean monthly temperatures for a year; (*b*) amount of rainfall recorded in each month; and (*c*) a wind rose showing predominant wind directions at your place.

Do not forget to write a suitable interpretation of the graphs prepared by you.

Finding Out

A jet plane is flying over Delhi at a height of 11,000 metres above sea level. The temperature and atmospheric pressure at Delhi are 20°C. and 74 cm. respectively. Find out the approximate temperature and pressure at the level of the jet plane. (Note that Delhi is situated at about 220 metres above sea level).

Making Simple Instrument

What are the basic principles that are to be kept in mind in order to measure the rainfall of a place accurately? Devise a simple rain-gauge and measure the rainfall at your school.

Preparing a Conversion Table

Draw an accurate diagram of a thermometer on a large sheet of paper. Mark the boiling and freezing points along its tube and graduate graphically and accurately the tube to show the degrees of Fahrenheit on the left hand side and the degrees of centigrade on the right hand side. Compare and check the two scales mathematically.

Map Readings

Study carefully the weather map given in the text and answer the following questions:

(*i*) Name the parts where the Highs and Lows lie.

(*ii*) In what part of the country is the sky overcast?

(*iii*) State the maximum and minimum values of atmospheric pressure depicted on the map.

(*iv*) Name the direction of winds off the Bombay coast and state their velocity.

(*v*) What are the symbols used for depicting
(*a*) Lightning; (*b*) Thunderstorm; (*c*) Snow; (*d*) Dust storm; and
(*e*) Calm sea?

Films Available

(*i*) The Weather. No. 551.5; 11 mins; English; D.A.V.E.

(*ii*) Weather For Tomorrow. No. 551.59; 12 mins; Hindi; D. A. V. E.

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U.S.I.S., *Watching the Weather from Space*. U.S.I.S., New Delhi, 1965. Pp. 1-75.

CHAPTER 7

Local Geography

LOCAL GEOGRAPHY deals with the study of the natural and cultural elements of man's immediate environment as they affect him. The mode of conduct of local studies or field work is as important as the contents of local geography. It emphasizes direct observation and a first-hand collection of relevant data pertaining to physical phenomena and human response.

Local geography gives a clear appreciation and understanding of the geographical principles relating to the physical and economic background of an area. It is, therefore, the starting point of all geographical knowledge.

The study of local geography is useful in various ways. A careful study of one's immediate neighbourhood or local region makes the understanding of distant regions more real and meaningful. It serves as a norm for making comparisons. It develops among its students a sense of distance, direction, precision, and proportion. It initiates students into the techniques and skills involved in making systematic observations and deducing intelligent conclusions therefrom. It develops an ability to correlate diverse elements and factors to establish meaningful relationships.

Besides developing an analytical mind which is necessary in making systematic observations, collection and processing of data, it also lends opportunities to develop an appreciation of a synthetic approach so peculiar to the subject of geography.

Finally, the field work involved in local geography lends opportunity for a student to relate himself to his environment and human institutions developed by man. In fact, this sense of belonging is the foundation on which rest the qualities of citizenship.

The approach to local geography varies according to the nature of the place where the observer is located. In an urban area, the emphasis is naturally placed on the economic activities of man, viz., commerce and industry, urban features of settlement, and means of transport and communication. In a rural area, the physical surroundings, viz., topography, hydrography, soils and vegetation receive the careful attention of the students of geography. Equally important is the study of land use, crops and their rotation, agricultural practices, centres of recreation, and periodic markets and fairs. Some places may require the study of their special activities such as mining, tourism, lumbering, fishing and shipping.

The study of local geography may be conducted on the following lines:

Locational Information

Usually a good deal of preliminary desk-work precedes actual field work. A careful study of local maps and topo-sheets lends useful data regarding location and extent of the area. Exact location of the given area is recorded in degrees and minutes of latitude and longitude. The actual extent of the area under study is found out with the help of the scale given on a map.

Certain important natural features like rivers and ranges help us to understand the principles involved in demarcation of administrative and political boundaries. In actual field work, it is of interest to locate and identify these relief features. Spot heights and bench marks give us an idea of the altitude of the places and area as a whole.

Historical Background: Another aspect of map study as well as of field work is to locate places of historical importance. These may include battlefields, forts, historical monuments and ancient places of worship. These give us some idea regarding the historical background of the region. In some cases, it is possible to relate these to certain geographical factors such as location and relief of the region.

Relief Features

The study of physical or relief features and their systematic observation and description helps us to understand their evolution or the continuous change they are undergoing as a result of denudation. In some areas a study of land erosion and measures taken to conserve soil are highly important.

Another aspect of study relates to drainage, and to water table with its seasonal fluctuations, if any.

Climate: Data regarding climate is gathered from the publications of the Meteorological Department since it is the range, averages and deviations from the normal over a long period that are important for deducing any valid conclusions.

The study of natural vegetation wherever it exists throws light on soil and climatic conditions.

Land Use Pattern

The land use pattern may vary from place to place depending upon the nature of the region. In urban areas the use of land for commerce, industry, administration, residence and recreation is of great significance, whereas in rural areas the use of land for agriculture, pastoral purposes and cottage industries is highly significant. The land under forests and natural vegetation, if any, also merit the attention of a student of geography.

Urban area : In urban areas information regarding production and distribution of goods is to be gathered systematically. This refers to industry and commerce. In respect of industries, their location, size, sources of raw materials, supply of skilled and unskilled labour and means of transport need the careful attention of field geographers.

The distribution of goods produced in a region depends upon the size and nature of its market or the total area it serves. The extent of the market depends upon marketing facilities, cheap and quick transport, modern means of communication, banking facilities and the number of potential customers for whom the goods are produced. Competition from other marketing centres is also an important factor. It may be of interest to collect information regarding residence of the people, local streets and markets, and recreational, educational and medical facilities available to the citizens.

Finally, information regarding the suitability of a site for the location and growth of a town in certain cases might be found interesting.

Rural Area: In rural areas the emphasis will be obviously on agriculture. Information regarding crops and their relationship with climate and soil will have to be observed carefully. The rotation of crops, irrigational facilities and agricultural practices followed by farmers should receive special attention.

It may be of interest to find out whether the agriculture practised in the region is of subsistence level or allows for surplus to be exported outside the region. Information regarding cash crops, rotation of crops, dairying and other activities of the farmers should receive due attention.

In certain areas the forest resources may play an important part in the economic acti-

vities of the people. It may be useful to note the types of natural vegetation, trees and plants of economic significance, and the subsidiary industries depending upon forest resources.

If the area is close to the urban centre, its influence on the rural activities may be observed. Interdependence of rural and urban areas can be a special topic of interest on which factual data can be collected systematically.

Finally, it may be of interest to note the progress being made by the rural areas as a result of various projects and activities undertaken by the Government under its Five-Year Plans. These may include increased irrigation and transport facilities, health and educational services, co-operatives, and recreational facilities.

Transport and Communication

In both rural and urban areas this is a subject of special interest for a field geographer. In urban areas even air and water transport facilities are to be noted carefully. Postal services, telegraph, telephone and wireless communication are important for the growth of commerce and industries. In rural areas the impact of growing transport and communication facilities, or the lack of them should be given the attention they deserve.

Appendix I

Representative Fractions with Their Metric and British Equivalents

Map scale (R. F.)	*One centimetre represents*	*One kilometre is represented by*	*One inch represents*	*One mile is represented by*
1 : 2,000	20 metres	50.0 cm	56 yards	31.68 inches
1 : 5,000	50 metres	20.0 cm	139 yards	12.67 inches
1 : 10,000	0.1 km	10.0 cm	0.158 mile	6.34 inches
1 : 20,000	0.2 km	5.0 cm	0.316 mile	3.17 inches
1 : 24,000	0.24 km	4.17 cm	0.379 mile	2.64 inches
1 : 25,000	0.25 km	4.0 cm	0.395 mile	2.53 inches
1 : 31,680	0.317 km	3.16 cm	0.5 mile	2.0 inches
1 : 50,000	0.5 km	2.0 cm	0.789 mile	1.27 inches
1 : 62,500	0.625 km	1.6 cm	0.986 mile	1.014 inches
1 : 63,360	0.634 km	1.58 cm	1.0 mile	1.0 inch
1 : 75,000	0.75 km	1.33 cm	1.18 miles	0.845 inch
1 : 80,000	0.8 km	1.25 cm	1.26 miles	0.792 inch
1 : 100,000	1.0 km	1.0 cm	1.58 miles	0.634 inch
1 : 125,000	1.25 km	8.0 mm	1.97 miles	0.507 inch
1 : 250,000	2.5 km	4.0 mm	3.95 miles	0.253 inch
1 : 500,000	5.0 km	2.0 mm	7.89 miles	0.127 inch
1 : 1,000,000	10.0 km	1.0 mm	15.78 miles	0.063 inch

Appendix II

Important Properties of Some Common Projections

Projection and its suitability	*Properties*
Simple Cylindrical (Suitable for mapping the areas in low latitudes, i.e., equatorial regions.)	1. It is neither equal-area nor orthomorphic. 2. All parallels are equal to the equator and all meridians are half of the equator in length. 3. Parallels and meridians are spaced at equal intervals. 4. Parallel scale is correct only along the equator. It gets exaggerated poleward. Meridian scale is correct throughout. 5. The poles are projected as straight lines.
Cylindrical Equal-Area (Suitable for representing countries adjoining the equator and also used for world distribution maps.)	1. It is equal–area but not orthomorphic. 2. All parallels are spaced unequally, becoming closer towards poles while all meridians are spaced at equal intervals. 3. Parallel scale is correct only along the equator. It gets exaggerated towards north and south. Meridian scale is not correct throughout. It diminishes towards the poles. 4. The poles are projected as straight lines.
Mercator's (Suitable for navigation maps, aviation maps and maps showing planetary winds or ocean currents.)	1. It is not equal-area but is othomorphic. 2. All parallels are projected equal in length to the equator and are spaced closer near the equator. All meridians are spaced at equal intervals. 3. Parallel scale is correct only along the equator. It gets exaggerated towards poles. Meridian scale gradually and proportionately increases towards poles. 4. The poles cannot be shown in this projection. 5. A straight line on this projection is a line of constant bearing, i.e., it shows correct directions. It is called a Rhumb Line.
Simple Conical with One Standard Parallel (Suitable for showing regions in mid-latitudes where latitudinal extent may be less than 20°.)	1. It is neither equal area nor orthomorphic. 2. Parallels are arcs of concentric circles and meridians are straight lines radiating from the centre at uniform angular intervals. 3. Parallel scale is correct only along the standard parallel while to the north and south of it, it is exaggerated. Meridian scale is correct every where. 4. The pole is projected as an arc of a circle.
Zenithal Equidistant (Suitable for polar regions not exceeding 30° in latitudinal extent around the the pole.)	1. It is neither equal area nor orthomorphic. 2. Parallels are equidistant concentric circles and meridians are evenly spaced radiating lines from the centre. 3. Every point is at its true distance and in the right direction from the centre, i.e., the pole. 4. Parallel scale is not correct as it increases rapidly away from the centre. Meridian scale is correct throughout.
Mollweide's (Suitable for world distribution maps.)	1. It is equal–area but not orthomorphic. 2. Parallels are horizontal straight lines spaced closer near the poles. Meridians except the central and the 90th one are ellipses. They are spaced at equal intervals. 3. Parallel scale and meridian scale are not correct throughout.

Appendix III

Topographic Maps of the Survey of India

THE SURVEY OF INDIA was established in 1767. Besides giving training to many British surveyors, it has trained many Indian surveyors who are held in high esteem. Since its establishment, this organization has published topographic sheets in a number of series.

The International Series

The scale of this series is 1 : 1,000,000. Each sheet extends over 4° of latitude and 6° of longitude. In this series, the elevation is shown in metres. These sheets are known as 1/m sheets or one to one million sheets.

India and Adjacent Countries Series

The scale of this series is also 1 : 1,000,000 but the whole country is divided into 4 X 4 degree sheets. That is, each map contains 4° of latitude and 4° of longitude. Indian maps in this series are numbered as 45, 46, 47...and so on. This series forms the base and also the basis of arrangement of all other topographic sheets of India. (Fig. 52).

Quarter-inch to a Mile Series

The maps of this series are on the scale of one inch to 4 miles or 1 : 253,440. In this series, each 4X4 degree sheet is subdivided into 16 equal sheets. These are called the degree sheets since each sheet covers 1° of latitude and 1° of longitude and are numbered from A to P, for example, 55A, 55B, 55C.. and 55P (Fig. 52).

Half-inch to a Mile Series

Half-inch sheets show an extent of 30′ of latitude and longitude and represent a scale of one inch to 2 miles or 1:126,720. These sheets are numbered with respect to their direction from the centre of the degree sheet. For example half-inch sheets of sheet No. 55A will be 55A/N. W., 55A/N. E., 55A/S. W. and 55A/S. E. (Fig. 52).

One-inch to a Mile Series

The R. F. of this series is 1 : 63,360. The maps drawn on this scale are undoubtedly the best known. This scale is capable of showing fairly accurate details. Each sheet covers approximately 1800 square kilometres and shows an extent of 15′ of latitude and longitude.

In this series, each degree sheet is subdivided into 16 parts. These sheets are called one-inch topographic sheets. In other words, if each quarter-inch sheet is divided into 16 parts, they become one-inch maps. They are numbered as 55A/1, 55A/2,.... and 55A/16; and 55B/1—16. . . .55P/1 to 16 (Fig.52). For the change-over from the British System to the Metric System, the following metric scales have been specified for topographic maps.

One centimetre to 2.5 kilometres	(1 : 250,000)
One centimetre to one kilometre	(1 : 100,000)
One centimetre to 0.5 kilometre	(1 : 50,000)

The topographic sheets issued by the Survey of India may be had from

1. The Director, Map Division, Survey of India, Hathibarkala, Dehra Dun.

2. The Deputy Director, Map Publication, Survey of India, 13, Wood Street, Calcutta-16.

3. The Incharge, Map Sales Office, Survey of India, Janpath Barracks 'A', First Floor, New Delhi-1

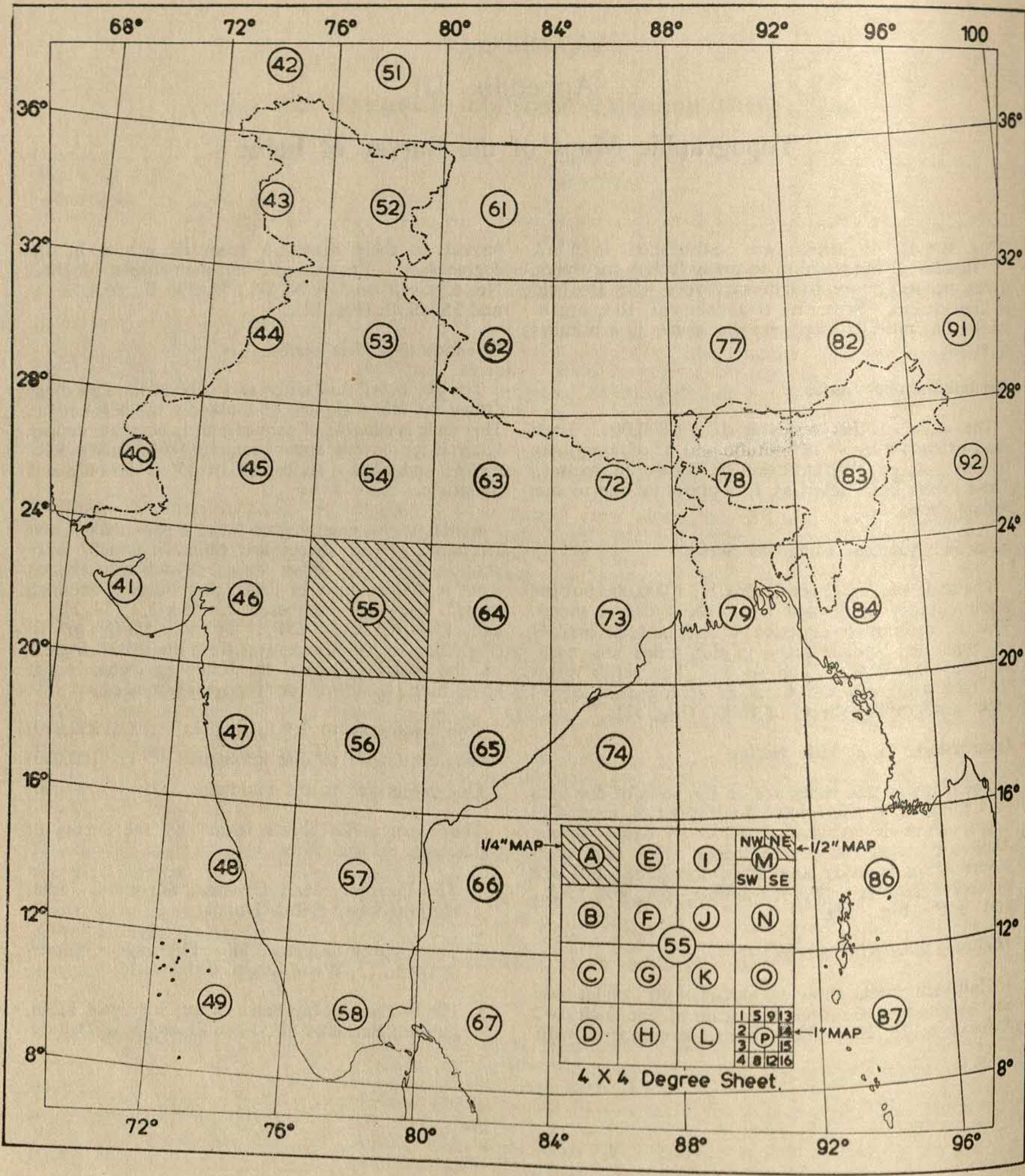

Fig. 52. Arrangement of Topographic Sheets Published by the Survey of India

From the map, how would you explain the numbering of 4 X 4 degree sheets, quarter-inch sheets, half-inch sheets and one-inch sheets?

Appendix IV

Altitudes, Pressures and Temperatures

Altitude (metres)	*Pressure (millimetres)*	*Temperature (°C.)*	*Altitude (metres)*	*Pressure (millimetres)*	*Temperature (°C.)*
—500	806.2	+18.3	6,000	353.8	—24.0
0	760.0	15.0	6,500	330.2	—27.3
500	716.0	11.7	7,000	307.8	—30.5
1,000	674.1	8.5	7,500	286.8	—33.7
1,500	634.2	5.2	8,000	266.9	—37.0
2,000	596.2	+2.0	8,500	248.1	—40.3
2,500	560.1	—1.2	9,000	230.5	—43.5
3,000	525.8	—4.5	9,500	213.8	—46.7
3,500	493.2	—7.8	10,000	198.2	—50.3
4,000	462.2	—11.0	10,500	183.4	—53.3
4,500	432.9	—14.2	11,000	169.7	—55.0
5,000	405.1	—17.5	11,500	156.9	—55.0
5,500	378.7	—20.8	12,000	145.0	—55.0

Appendix V

Relative Humidity as a Percentage

THE RATIO between the actual humidity of air and its maximum capacity to hold moisture at a given temperature is known as relative humidity. It is always expressed as a percentage. After taking the dry bulb and wet bulb readings at a given place and time, the relative humidity can be found from a table. This table has been standardized on the basis of many observations and experiments conducted at the normal pressure of 76 centimetres at sea level.

Suppose for any sample of air at a certain place, the temperature, that is, the dry bulb reading, is 90° F. and the wet bulb reading is 82°F. The difference between the two is 8°F. Now find out 90°F. in the 'Dry bulb temperature' column, and 8 in the 'Difference in degrees between dry bulb and wet bulb readings' line. At the intersection of 90°F. and 8, you get the number 71 which is the relative humidity expressed as a percentage for that instant of time at that place.

When dry bulb and wet bulb readings are the same, the relative humidity is 100 per cent, that is the air has reached its saturation point.

Dry bulb temperature in °F.	*Difference in degrees between dry bulb and wet bulb readings*													
	1	2	3	4	6	8	10	12	14	16	18	20	25	30
0	67	33	1											
5	73	46	20											
10	78	56	34	13										
15	82	64	46	29										
20	85	70	55	40	12									
25	87	74	62	49	25	1								
30	89	78	67	56	36	16								
35	91	81	72	63	45	27	10							
40	92	83	75	68	52	37	22	7						
45	93	86	78	71	57	44	31	18	6					
50	93	87	80	74	61	49	38	27	16	5				
55	94	88	82	76	65	54	43	33	23	14	5			
60	94	89	83	78	68	58	48	39	30	21	13	5		
65	95	90	85	80	70	61	52	44	35	27	20	12		
70	95	90	86	81	72	64	55	48	40	33	25	19	3	
75	96	91	86	82	74	66	58	51	44	37	30	24	9	
80	96	91	87	83	75	68	61	54	47	41	35	29	15	3
85	96	92	88	84	76	70	63	56	50	44	38	32	20	8
90	96	92	89	85	78	71	65	58	52	47	41	36	24	13
95	96	93	89	86	79	72	66	60	54	49	44	38	27	17
100	96	93	89	86	80	73	68	62	56	51	46	41	30	21
105	97	93	90	87	81	74	69	63	58	53	48	43	33	23
110	97	93	90	87	81	75	70	65	60	55	50	46	36	26

Appendix VI

The Beaufort Scale for Estimating Wind Speed

Beaufort number	*Wind*	*Wind speed (km/hr)*	*Noticeable effect of wind speed*
0	Calm	1	Smoke rises vertically.
1	Light air	1—6	Wind direction shown by smoke drift but not by wind vanes.
2	Slight breeze	7–12	Wind felt on face; leaves rustle; wind vanes moved by wind.
3	Gentle breeze	13–18	Leaves and twigs in constant motion; wind extends light-flag.
4	Moderate breeze	19–26	Raises dust and loose paper; small branches are moved.
5	Fresh breeze	27–35	Small trees in leaf begin to sway.
6	Strong breeze	36–44	Large branches in motion; whistling in telegraph wires; umbrellas used with difficulty.
7	Moderate gale	45–55	Whole trees in motion; inconvenience felt when walking against wind.
8	Fresh gale	56–66	Twigs break off; progress generally impeded.
9	Strong gale	67–77	Slight structural damage occurs; chimney tops and hanging signs blown away.
10	Whole gale	78–90	Trees uprooted; considerable structural damage.
11	Storm	91–104	Very rarely experienced; accompanied by widespread damage.
12	Hurricane	above 104	Very violent and destructive.

Appendix VII

Film References and Further Readings

Brief information regarding films has been given at the end of each Chapter under the head 'Films Available'. In each case the title of the film is followed by a procurement number if any, the length of the film in terms of time mentioned in minutes, the language in which the commentary is made and the name of the agency which loans the film. The name of the agency is given in abbreviation. The full name and address of agencies and their branches are given below to help the schools to procure films mentioned. It is further expected that a teacher would preview the film before it is shown to the class, prepare the class to understand its theme and finally, follow up the film show with a class discussion on the contents of the film.

1. B.I.S.: British Information Services, Film Libraries New Delhi, Chanakyapuri, New Delhi-21.

   Bombay—Mercantile Bank Building, Mahatma Gandhi Road, Fort, Bombay-1.

   Calcutta—1 Harrington Street, Calcutta-16.

2. C.H.C.: Canadian High Commission, Film Library, 13, Golf Links, New Delhi-3.

3. D.A.V.E.: Department of Audio Visual Education, Central Film Library, Indraprastha Estate, Ring Road, New Delhi.

Listed at the end of each Chapter are the references for further reading. In each case the name of the author, title, publisher, place and year of publication, and the actual numbers of the pages having a bearing on the topic discussed in the text have been given. These may be used as collateral readings for further enrichment of students. The books with an asterisk mark are essentially meant for the use of teachers. However, he is expected to be familiar with the other books as well. The books mentioned below are meant for general reference.

Stamp, L.D., *A Glossary of Geographical Terms.* Longmans, Green and Co. Ltd., London, 1961.

Moore, W.G., *A Dictionary of Geography.* Penguin Books Ltd., Harmondsworth, Middlessex, 1959.

Government of India, *School Atlas.* Map Publication Office, Survey of India, Dehra Dun, 1964.

Parakh, B.S., *Functional Assignments in Geography.* National Council of Educational Research and Training, New Delhi, 1961. (A non-priced publication and can be had from the Publication Unit, NCERT, B-31, Maharani Bagh, New Delhi-14.)

GLOSSARY

Anemometer—An instrument meant for measuring wind speed. It comprises a system of cups and a speed indicator.

Aneroid Barometer—A portable instrument commonly used for measuring atmospheric pressure. It consists of a partially vacuumed metallic box, a flexible lid and a needle working on a lever. A change in atmospheric pressure is indicated by the motion of the elastic and sensitive top of the box.

Atlas—A collection of maps bound into a volume. Generally, these maps are drawn on small scales. The term *atlas* first appeared on the title page of the collection of Mercator's charts in A. D. 1595. The origin of the word, however, further goes back into the past, as it relates to 'Atlas' supporting the heavens according to mythological beliefs.

Azimuthal projections—A type of map projections in which a portion of the globe is projected upon a plane tangent to the globe at some specific point, for example the North or the South Pole. These projections are also known as True Bearing Projections because all points have their true compass direction from the centre of the map drawn on these projections. The word *azimuth* means 'bearing' or 'direction'.

Bar graph—A series of columns or bars drawn proportional in length to the quantities they represent. They are drawn on a selected scale. They may be drawn either horizontally or vertically.

Barometer—An instrument for measuring atmospheric pressure which is the weight of the air column at a given place and time. Fortin's and aneroid barometers are examples of such an instrument.

Bench mark—Exact height of specific points on prominent and durable material objects like rocks or buildings in the field, recorded for the sake of permanent reference. On a map, bench mark is indicated by the letters B. M. followed by the number giving the actual height of the mark above mean sea level.

Cadastral maps—Maps drawn on a fairly large scale to show accurately the extent and measurement of every field and plot of land. The word *cadastre* means 'a public register of the lands of a country for defining property and levying taxes.'

Cartogram—The representation of statistical data on a map in a diagrammatic way by purposefully distorting the original shape etc. of the area concerned. Usually, it is a highly abstracted and simplified map highlighting a single idea in a diagrammatic way. It is one of the important and popular tools of modern geography.

Cartography—The science of preparing all types of maps and charts and includes every operation from original surveys to the final printing of maps.

Central Meridian—When a meridian, whatever its value, stands at the centre of the projection it is called the central meridian and has nothing to do with the Prime Meridian as such.

Chain—A surveying chain is a length-measuring device used for the purpose of obtaining horizontal distances between two points. Chains are of various lengths, e.g., Metric chains of 20 and 30 metres each, the Engineer's chain of 100 feet and the Gunter's chain of 66 feet.

Chain survey—Measuring of horizontal distances by the chain and the tape. This relatively simple method is used for surveying small areas along with their details with reasonable accuracy.

A Climatic map—A map of the world or its part showing average conditions of temperature, pressure, wind, precipitation, and sky conditions over a period of time.

Conical projections—A type of map projections in which a map is projected on a paper cone imagined to be either resting on the globe or intersecting it in a particular manner. A conical projection may be with one standard parallel or with two standard parallels.

Contours—Imaginary lines joining all the points of equal elevation or altitude above mean sea level. They are also called 'level lines'.

Contour interval—Interval between two successive contours. It is also known as vertical interval, usually written as V. I. Generally, it is constant for a given map.

Cross-section—A side view of the ground cut vertically along a straight line. It is also known as a section or a profile.

Cylindrical equal-area projection—A kind of cylindrical projection in which the area between two parallels is made equal to the corresponding surface on the globe by decreasing the distance between the parallels progressively towards the poles.

Cylindrical projections—A group of projections in which a cylinder is presumed to have enveloped or cut the globe in a particular manner. All cylindrical projections form rectangles.

Diagonal scale—An elaboration of the graphic scale by which one can measure up to a minute part of a centimetre or an inch. It gives divisions much smaller than the secondary divisions of a graphic scale.

Distribution maps—Maps which, with the aid of certain symbols like dots and shading schemes, depict location of various geographic elements and their frequency or intensity or density as the case may be. For example they may show distribution of crops, livestock, population, industrial output etc., in a given area.

Drainage—A system of rivers or streams which drain all the rain-water that falls in a region.

Fortin's barometer—A weather instrument capable of recording accurate atmospheric pressure. It works on the principle of weighing a column of air against the column of mercury. The instrument is heavy and cannot be easily trnasported.

Great Circle—A circle on the earth's surface whose plane passes through the centre of the earth bisecting it into halves. The shortest distance between any two points on the earth's surface is along the arc of a great circle.

Hachures—Small straight lines drawn on the map along the direction of maximum slope, running across the contours. They give an idea about the differences in the slope of the ground.

Hill-shading—A method of showing relief on a map by shading only those slopes that face south and east; presuming that the source of illumination is in the north-west.

Homolographic projection—A projection in which the network of latitudes and longitudes is developed in such a way that every graticule on the map is equal in area to the corresponding graticule on the globe. It is, therefore, also known as equal-area projection.

Interpolation of contours—Drawing contours with the help of spot heights given on the map.

Isobars—Imaginary lines drawn on a map joining places with equal barometric pressure, reduced to sea level, in order to eliminate differences due to varying altitudes.

Isohyets—Imaginary lines drawn on a map joining places with equal amount of rainfall over a given period of time.

Isotherms—Imaginary lines drawn on a map joining places with equal temperature, reduced to sea level.

Land use—The use which is made by man of the surface of the land. In sparsely populated areas it includes occupation of land by natural and semi-natural vegetation.

Layer colouring—A method of showing relief with the help of contours especially in atlas and wall maps. The contour scheme is followed universally; for example, shades of blue for sea, green for low-lying areas, brown for higher and pink for still higher lands.

Linear scale—A method of expressing scale with the help of a line conveniently divided and sub-divided so that distances on the map can be directly measured and read off from a map.

Line graph—A smooth line drawn through a series of points which are determined by means of two co-ordinates along the X-axis and the Y-axis. Change in one variable is shown with reference to another. Usually it is used for presenting data regarding rainfall, temperature, growth of population, production, etc.

Local geography—A study of natural and cultural elements of man's immediate environment as they affect him, or are modified by him. For a student of geography it emphasises direct observation and collection of first hand data and their interpretation.

Magnetic North—The direction pointed to by the needle of the magnetic compass. It is determined with reference to the Magnetic North Pole, which is different from the North Pole and also moves slowly from time to time.

Map—A conventional representation of any area of the earth's surface, small or large drawn to scale on a flat surface, as seen from vertically above.

Map projection—A method of transferring the network of parallels and meridians, i.e., earth's grid, from the spherical surface of the earth to a plane surface.

Maximum and minimum thermometer—An instrument which is used to register the highest and the lowest temperatures during a given period. It saves man the trouble of keeping a constant watch on the instrument.

Mercator's projection—A type of cylindrical orthomorphic projection in which constant bearings are maintained as meridians and parallels intersect each other at right angles. It is highly useful for navigational purposes.

Meridian scale—The distance along a meridian of longitude which is measured between two parallels of latitude.

Mollweide's projection—A kind of equal-area or homolographic projection in which the globe is represented by an ellipse. It has a pleasing shape and is used for distribution maps.

Optical square—An instrument used in chain survey for setting out right angles for measuring short distances from the chain line to the objects nearby.

Orthomorphic projection—A type of projection in which every care is taken to preserve the correct shape of a given area of the earth's surface. It is, therefore, also known as a correct shape projection.

Pantograph : An instrument used for enlargement and reduction of maps with accuracy.

Parallel scale—The distance along a parallel of latitude which is measured between two meridians. The parallel scale is always correct along the standard parallel.

Plane table—A surveying instrument by means of which a map of a small area may be drawn and completed in the field with a fair amount of accuracy. It is also useful for filling the details into a network of triangles.

Rain gauge—An instrument for measuring accurately the amount of rainfall at a given place over a fixed duration, say 24 hours.

Ranging rod—A wooden straight rod, coloured red and white, with a metal shod at one end to fix it securely in ground. Ranging rods are used in chain survey, plane tabling and other methods of surveying.

Relief—A collective name given to surface features of the earth such as mountains, plateaus, plains, valleys and water bodies. The elevations and depressions of land surface such as mountains, plains and valleys are called relief features.

Relief map—A map showing relief of an area on a flat surface by means of any of the methods such as contours, form-lines, layer colouring, hachures, hill-shading or a combination of these.

Rhumb line—A straight line of constant bearing intersecting all intermediate meridians at the same angle in a given projection.

Scale—The ratio which a distance between any two points on a map bears to the actual distance between the corresponding points on the ground.

Spot height—The exact height of a given spot found out with the help of surveying instruments. It is shown on a map by a dot followed by a number expressing the height in metres or feet.

Standard parallel—The parallel of latitude of any projection along which the scale is true.

Surveying—It is an art of making observations and measurements both linear and angular, in order to determine the relative position of points on the earth's surface. It helps to determine the boundaries, extent, position and relief of any part of the earth's surface.

Thermometer—An instrument used for measuring temperature.

Topographic map—A map of a small area drawn on a large scale depicting detailed surface features both natural and man-made. Relief in this map is shown by contours.

True North—The direction towards which the North Pole of the earth points. It is also known as Geographic North.

Watershed—A narrow elevated tract of ground separating water flowing in opposite directions.

Weather—The condition of the atmosphere at a given place and time with respect to atmospheric pressure, temperature, humidity, precipitation, cloudiness and wind. These factors are known as weather elements.

Weather forecast—Prediction with a reasonable amount of certainty the conditions of weather that would prevail in the coming 12 to 48 hours in a certain area.

Wet and dry bulb thermometer—An instrument used for finding out relative humidity, dew-point and vapour pressure with the help of tables.

Wheel diagram—A circular diagram in which a circle is divided into sectors for presenting data in percentage.

Wind rose—A diagram showing the frequency and direction of wind blowing from each of the eight directions at a given place, over a period of time.

Wind vane—An instrument used for determining wind direction.

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